NSSL's Warn-on-Forecast Research Project

Progress Report for Year 4

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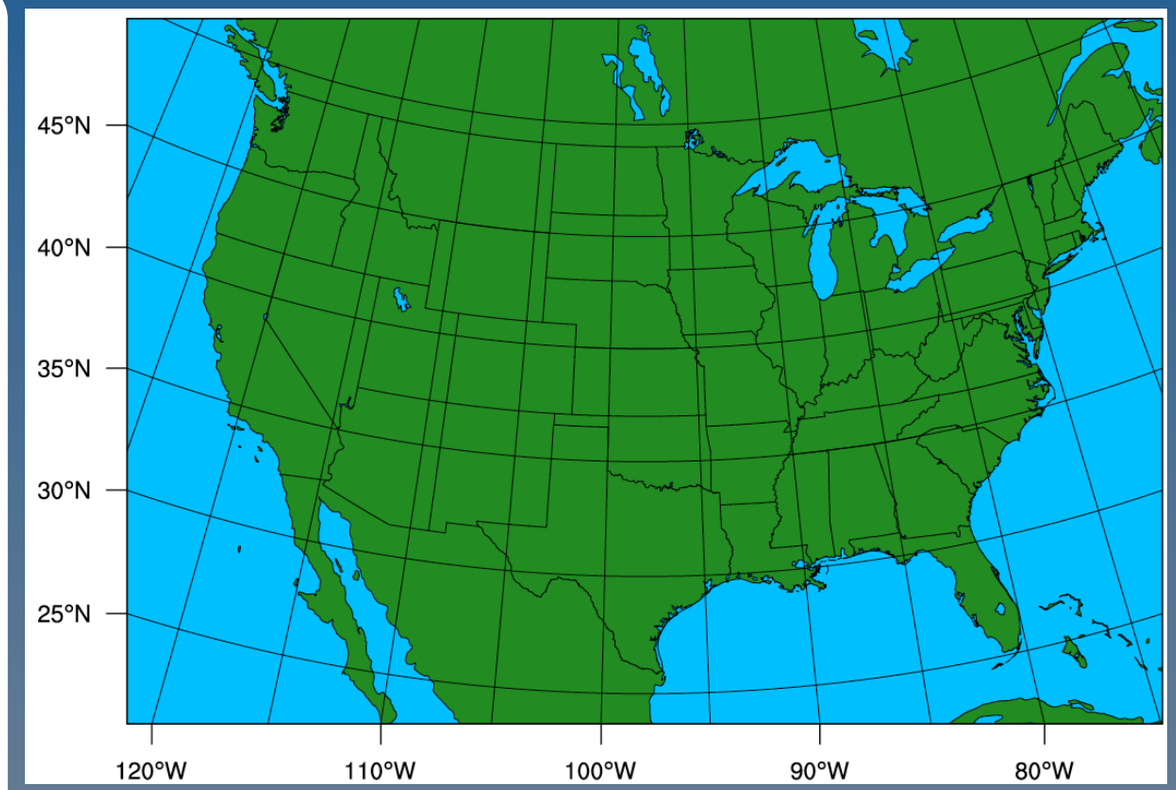
2014 Warn-on-Forecast Workshop

Major Activities

- NSSL Mesoscale Ensemble for HWT Spring Experiment
- 24 May Case studies
- Testing of various approaches
  - Ens3DVAR, Hybrid, LETKF+RIP
  - Generating Initial conditions for daily storm-scale prediction
- Non-central plains case work
- Best use of satellite and radar data together
- Assimilation of PAR radar data
- Other
  - display of probabilistic hazard information (PHI)
  - relation between dual-pol variables and tornadogenesis
  - resolutions needed in model to capture storm dynamics

NSSL Mesoscale Ensemble (NME)
HWT Spring Experiment

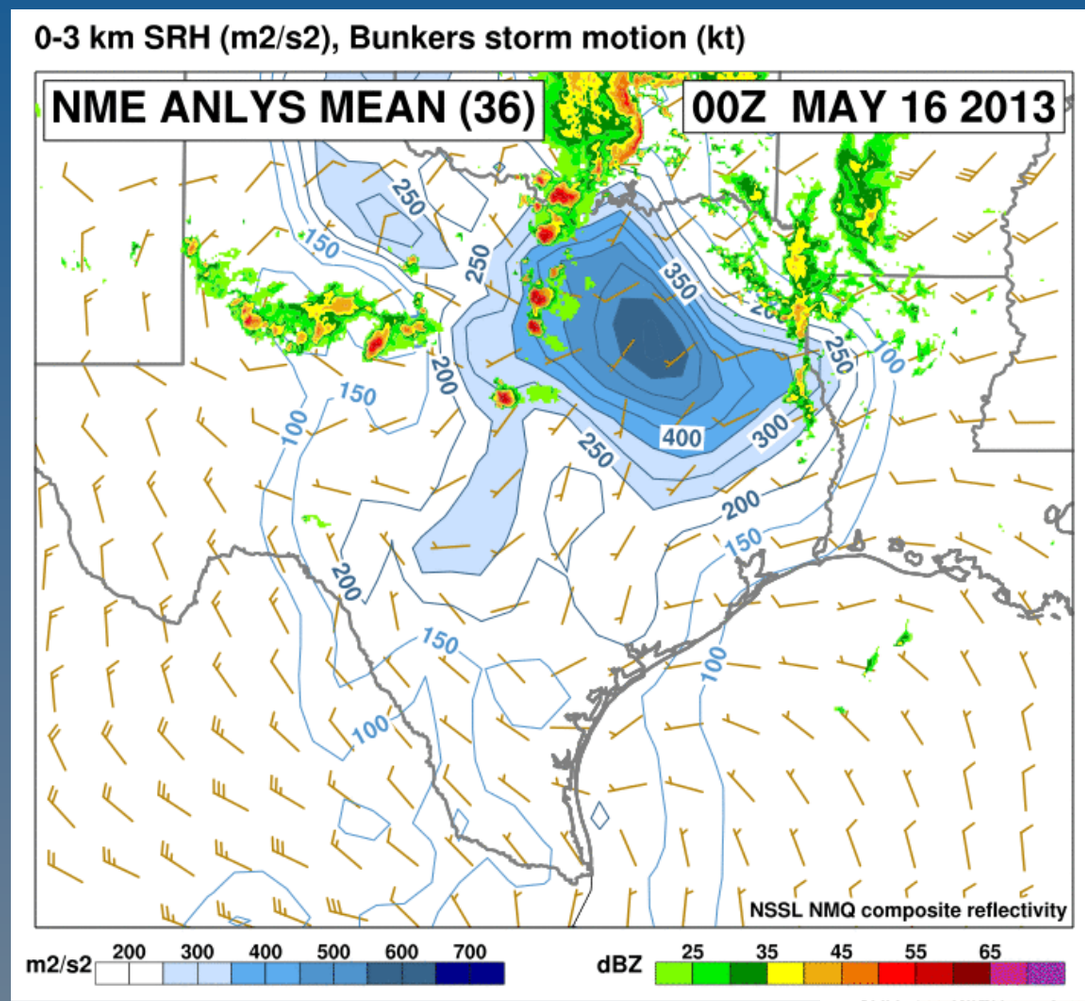
- WRF-ARW core
- 15-km CONUS Grid
- 36-members
- Initial and boundary conditions (ICs/BCs) derived from 1200 UTC cycle of the Earth System Research Laboratory-Rapid Refresh (ESRL-RAP)
  - ICs/BCs randomly perturbed via the Torn et al. 2006 method
- WRF-ARW physics diversity
  - Cumulus: Kain-Fritsch, Grell, Tiedtke
  - PBL: YSU, MYJ, MYNN2
  - SW/LW Radiation: Dudhia, RRTMG
- DA performed by DART software
  - EAKF (Anderson 2001)
  - Prior adaptive covariance inflation (Anderson 2009)
  - Gaspari and Cohn (1999) spatial localization

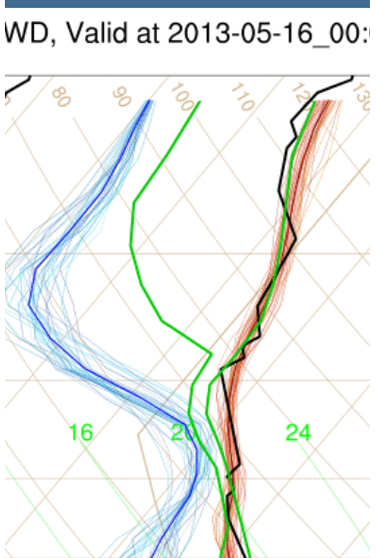


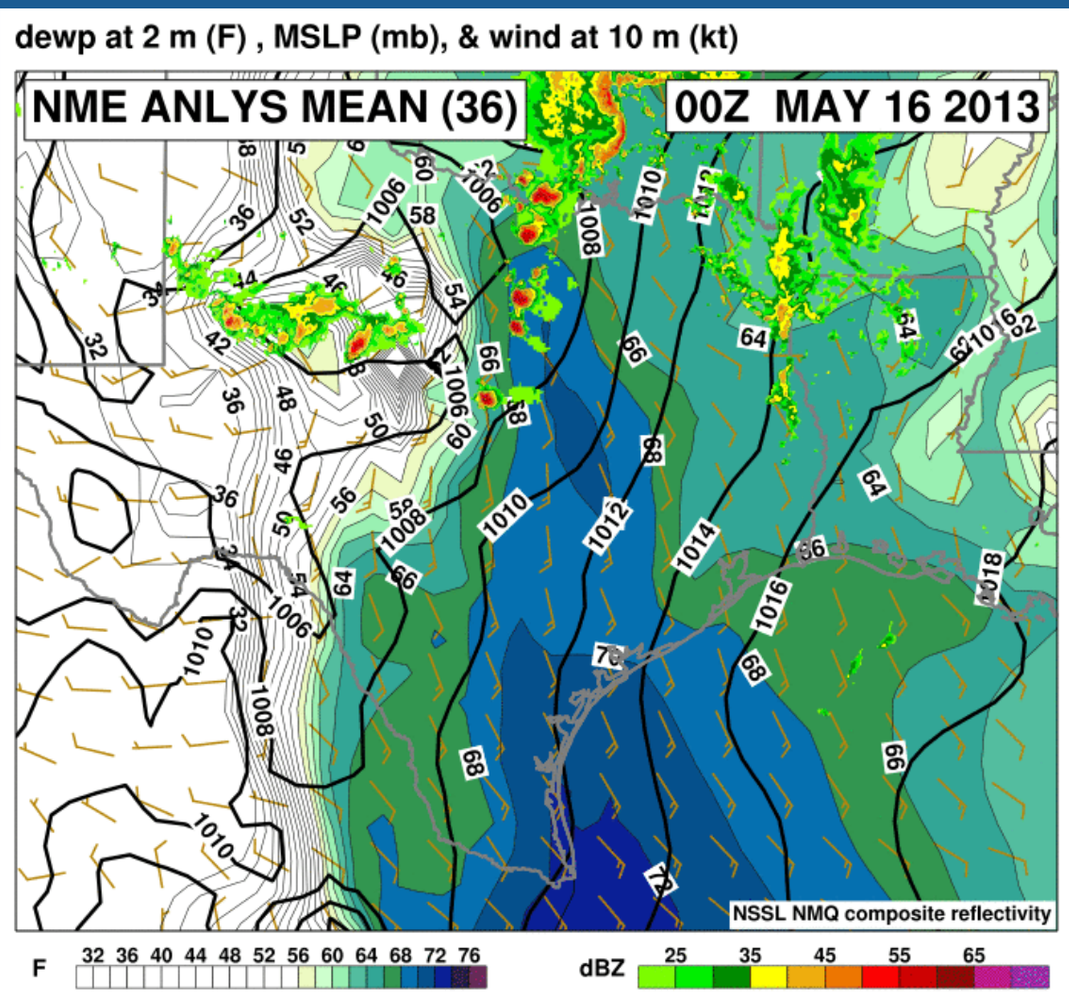
- Hourly analyses by T+30 min
- Forecast to 03Z every 3 hours
  FCST completed by T+70 min
- Required < 700 cores
  of OU Supercomputer

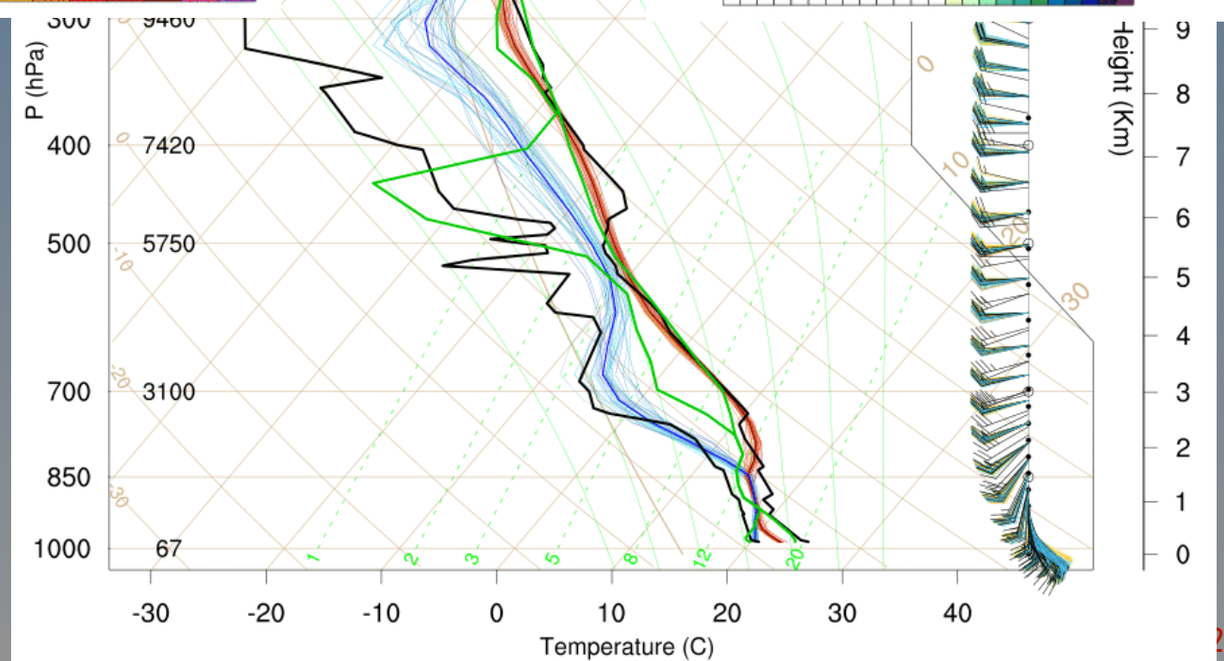
Purpose: to gain experience doing RT!

NME 15 May 2013 N. Texas Event



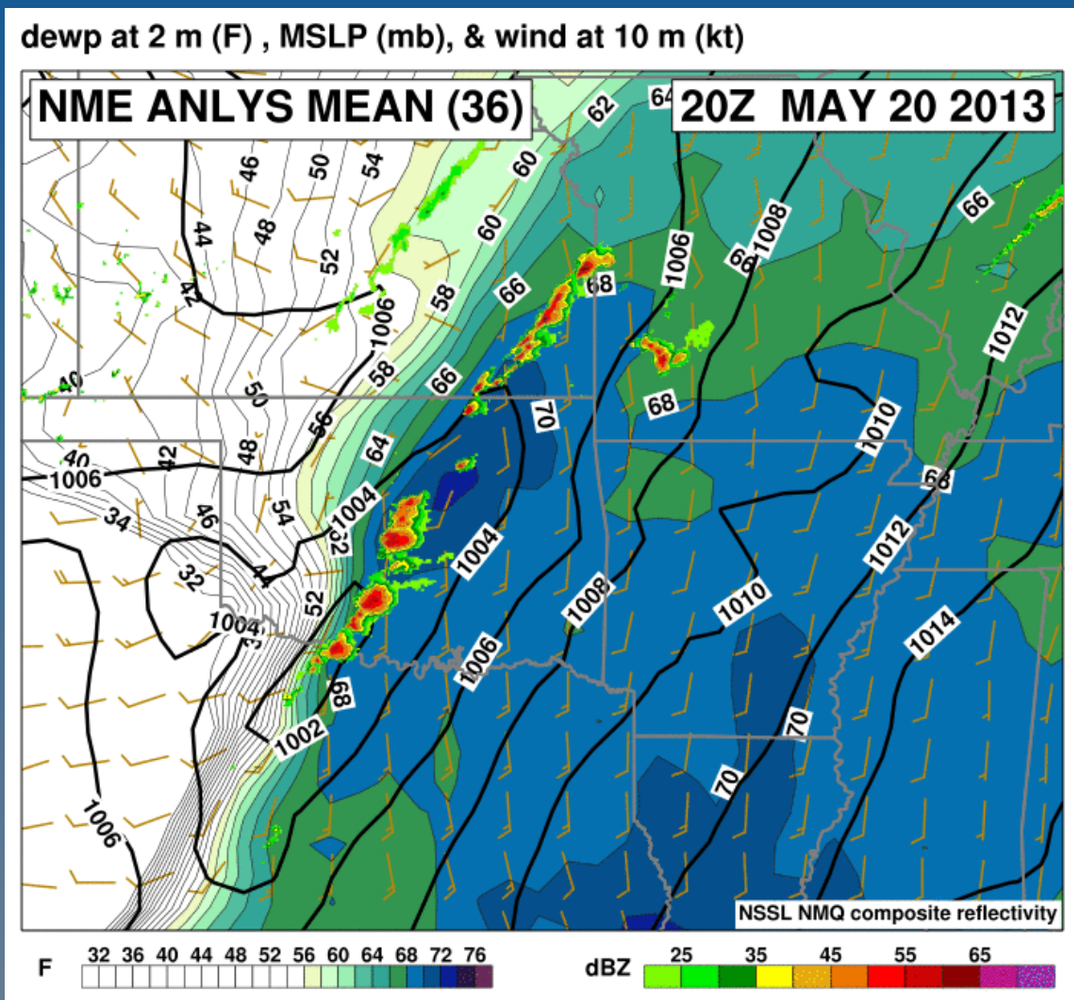


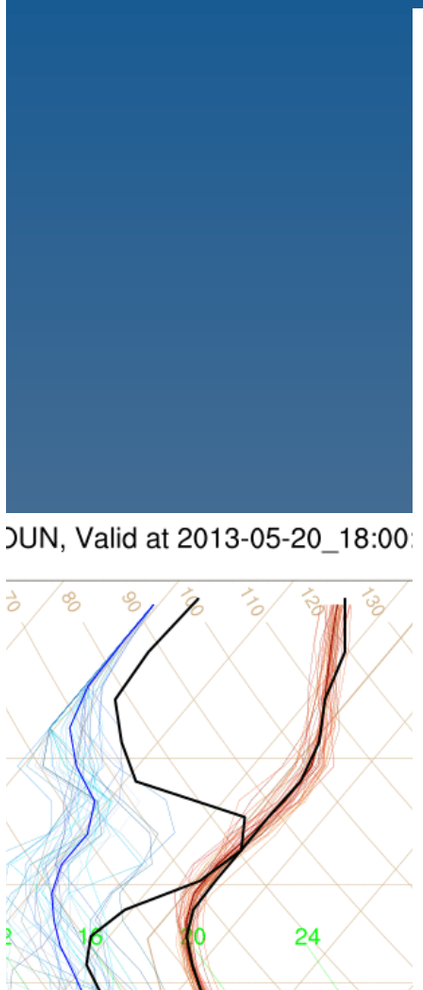


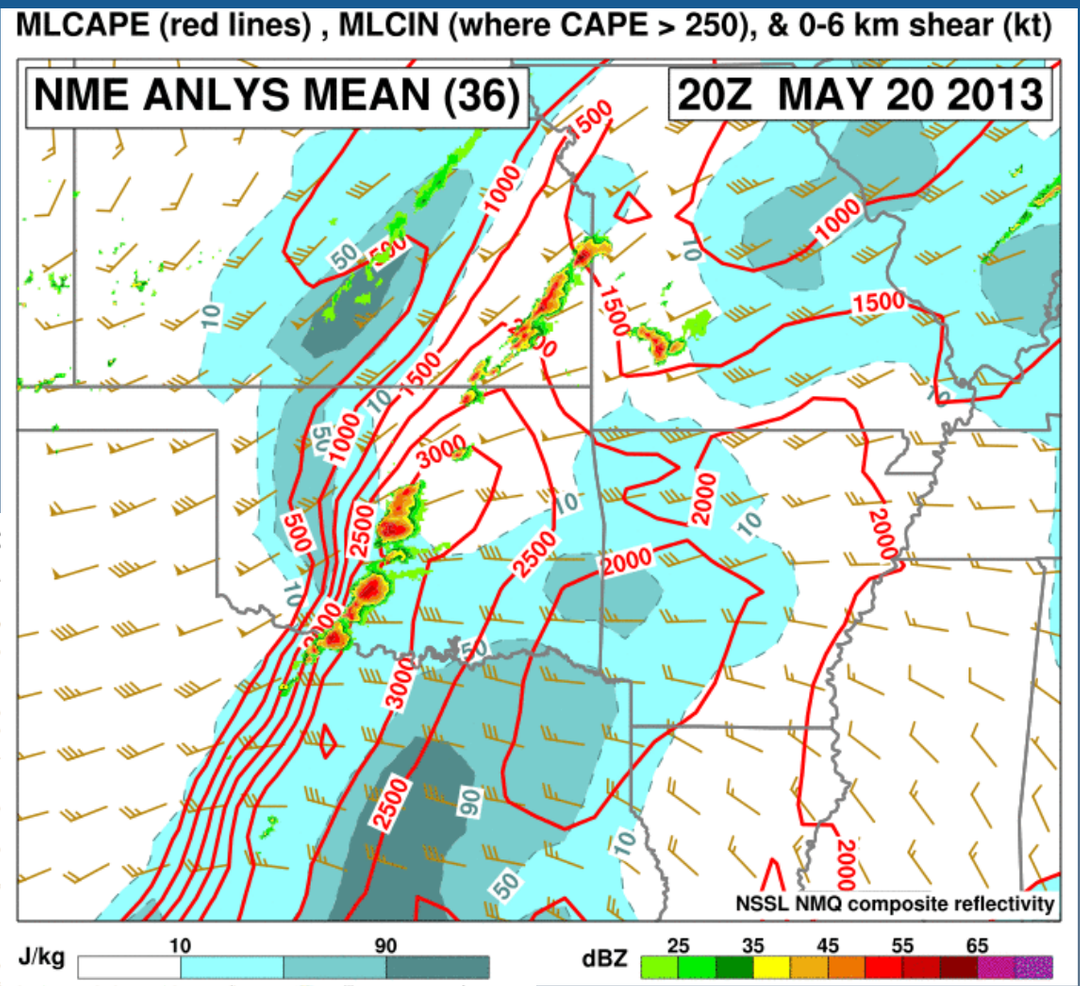


00Z FTW Snd vs Ensemble Snds

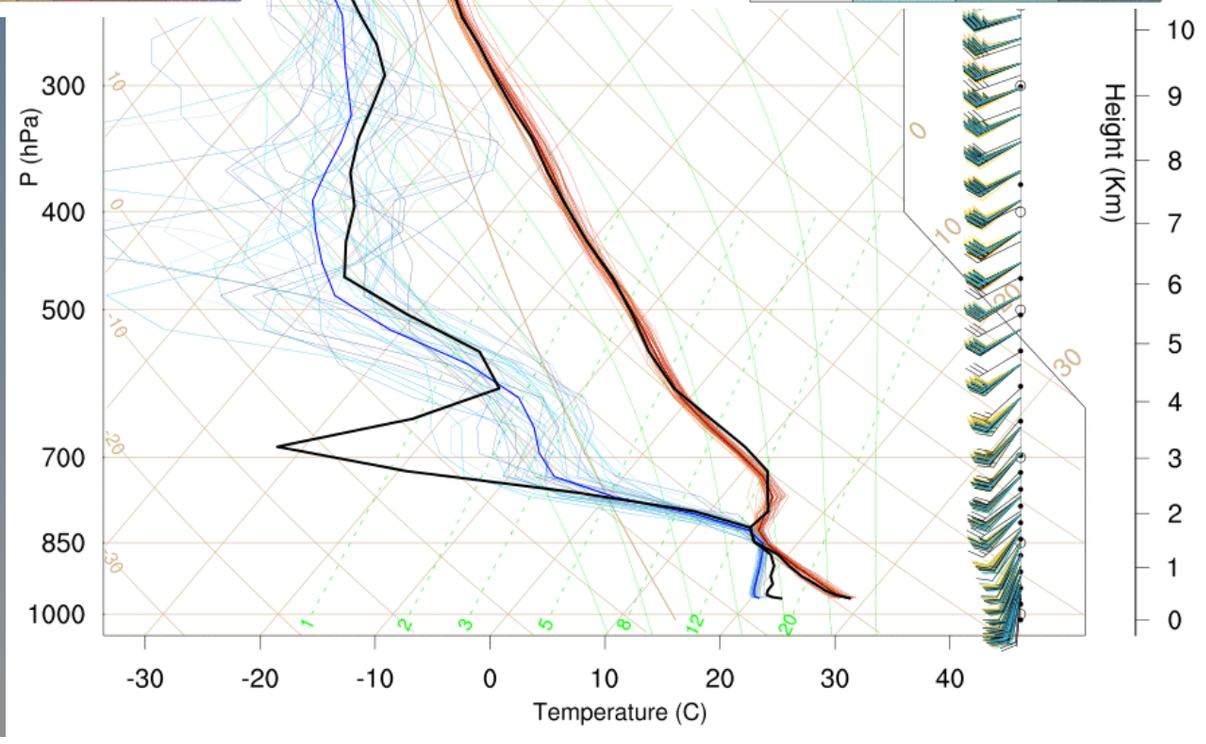
NME 20 May 2013 Moore Event





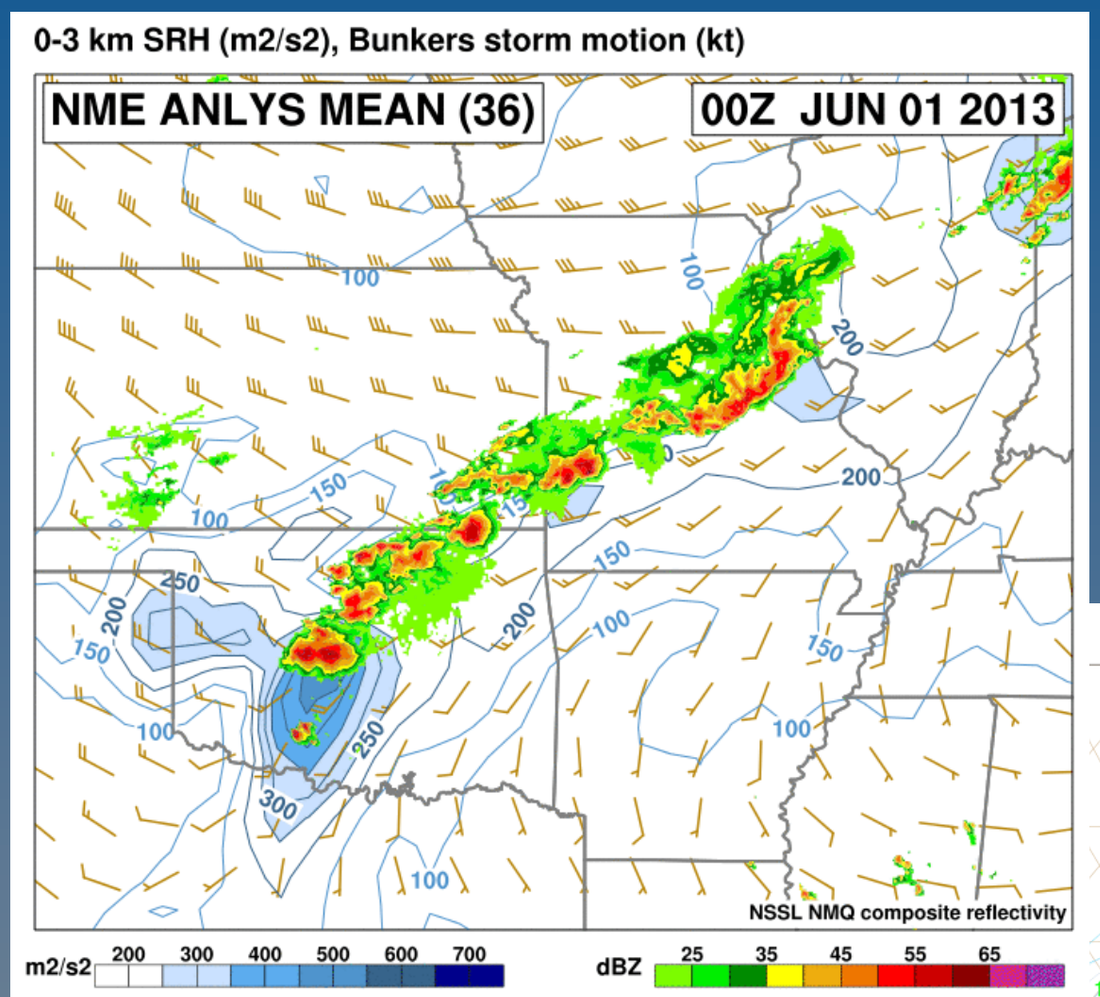


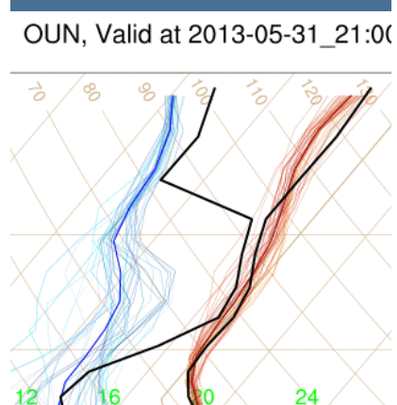
18Z OUN Snd vs Ensemble Snds

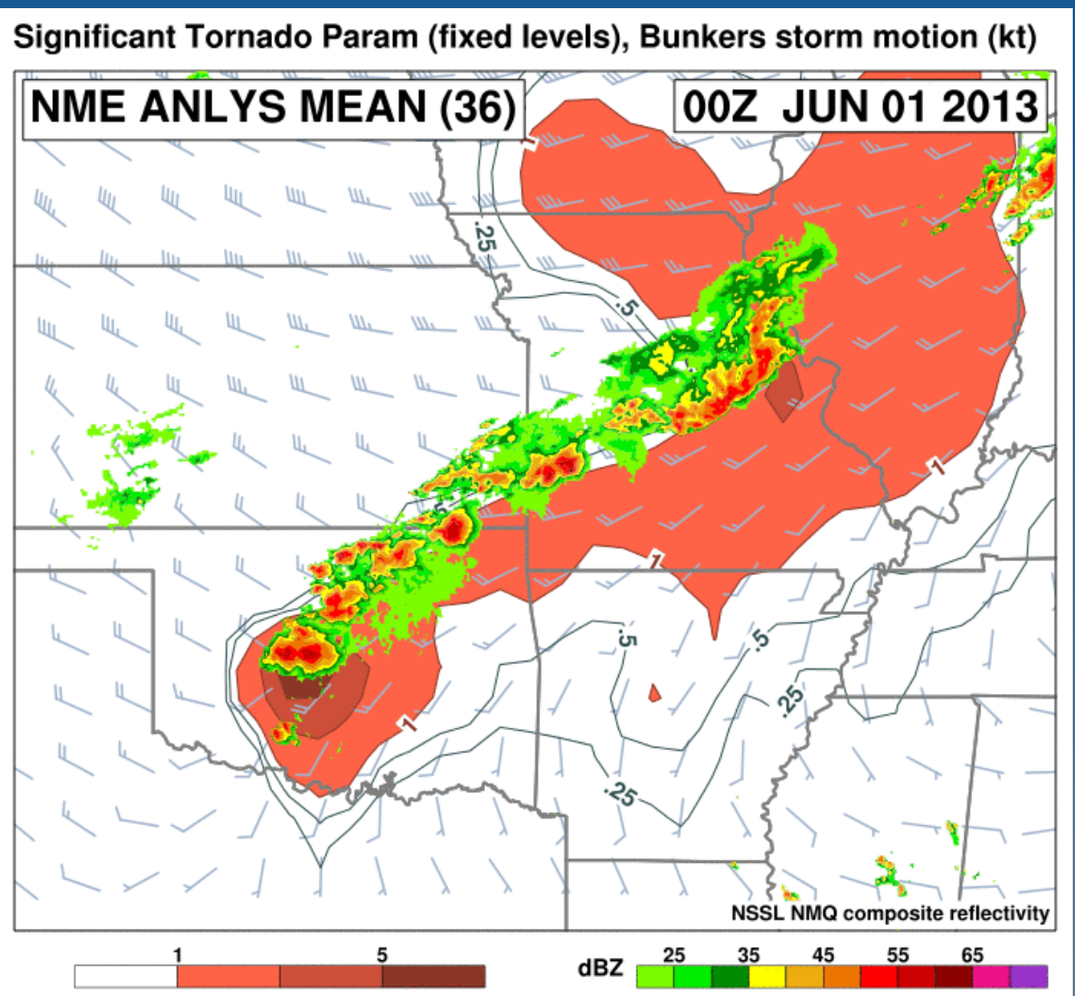


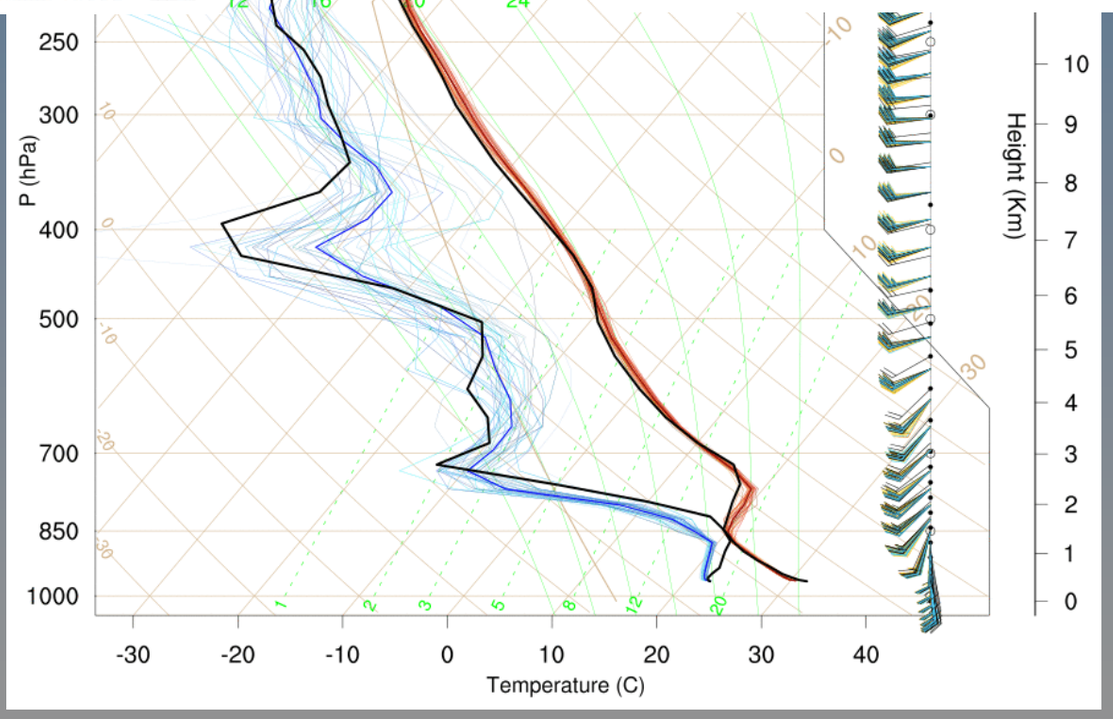
2014 Warn-on-Forecast Workshop

NME 31 May 2013 El Reno Event









00Z OUN Snd
vs
Ensemble Snds

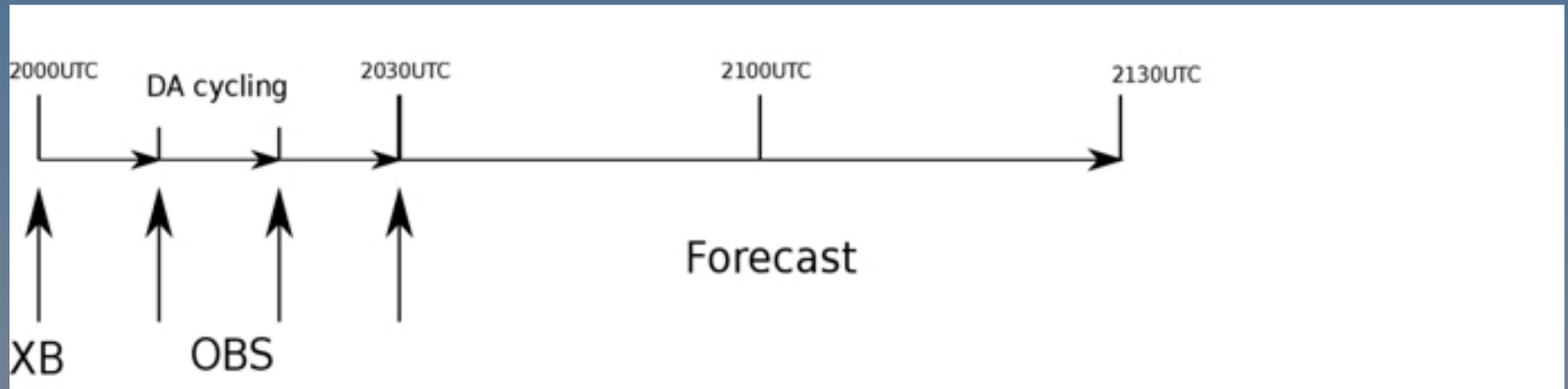
24 May 2011 Case Studies

- Evaluate various DA approaches on the “first” El Reno tornado (2011, not 2013!)
- 5 different experiments performed
  - –satellite + radar
  - –new initialization techniques + radar DA
  - –LETKF with running in place
  - –Ens3DVAR
  - –PAR rapid scan data impacts
- Trying to assess strengths and weaknesses of each approach
- Not a competition!! (*no wagering was allowed...*)

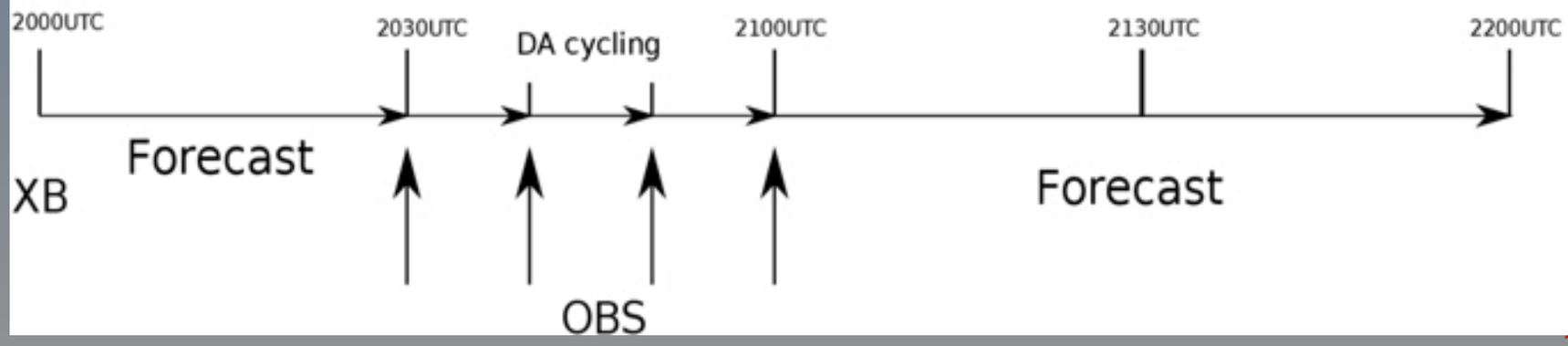
24 May 2011 Ens-3DVAR (Zhuang et al.)

- *3DVar and WRF ARW forecast cycle, using 36-member ensemble experiment with different combinations of physics schemes.*
- *Every 10 min DA cycling for half hour and 1hr forecasting*
- *Observations: radar Vr and cloud analysis, assimilation window: 3min*
- *Resolution is 3km×3km*

Exp1:



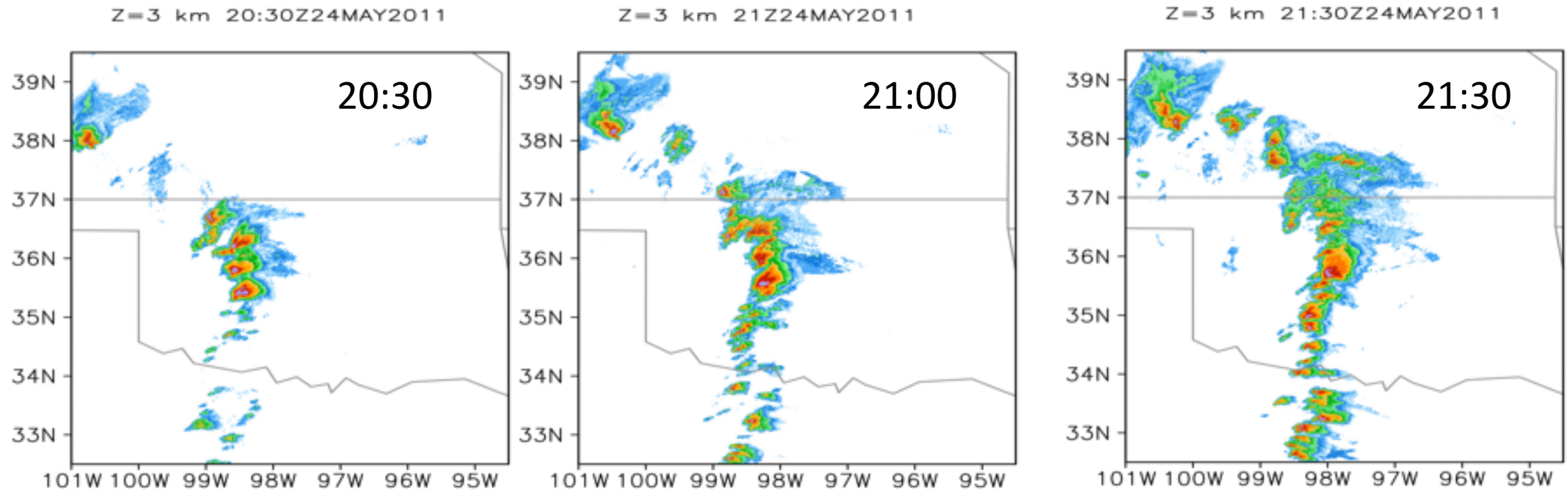
Exp2:



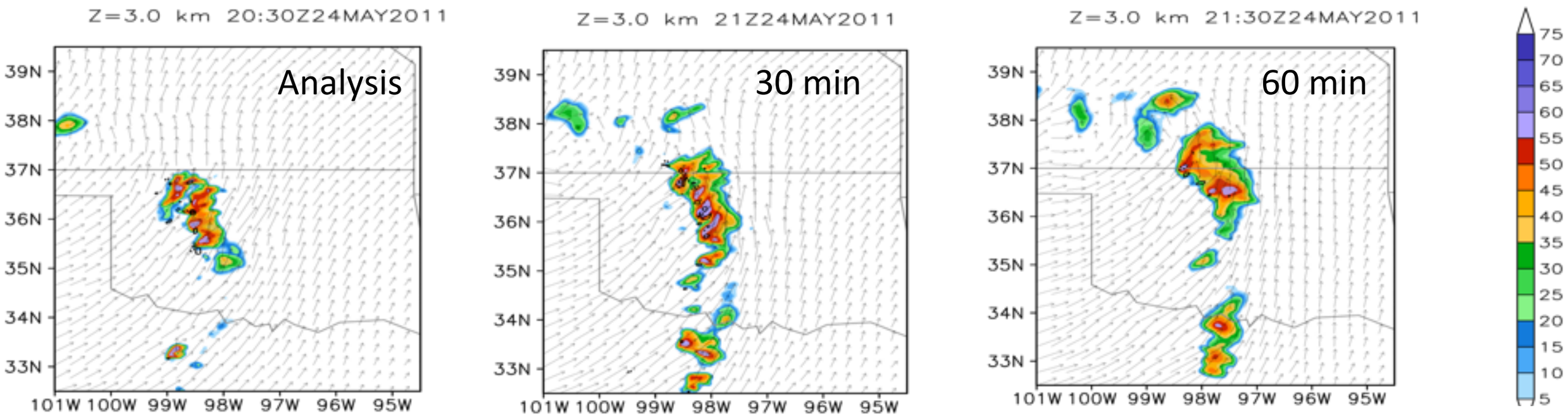
20:00-20:30 cycle, 1 hour FCST

Observed Radar Reflectivity

(Zhuang et al.)



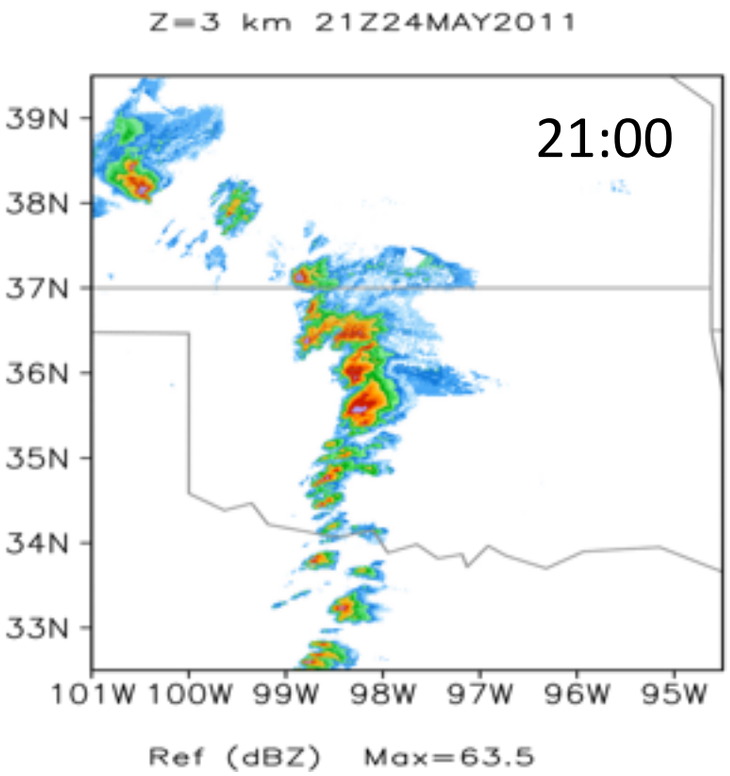
Forecast Reflectivity (color shaded),Wind vectors

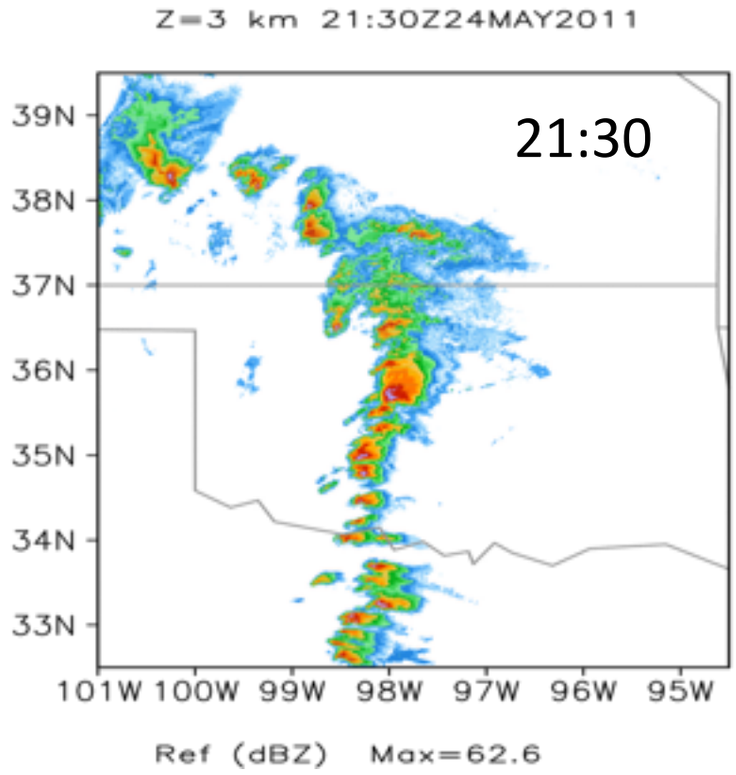


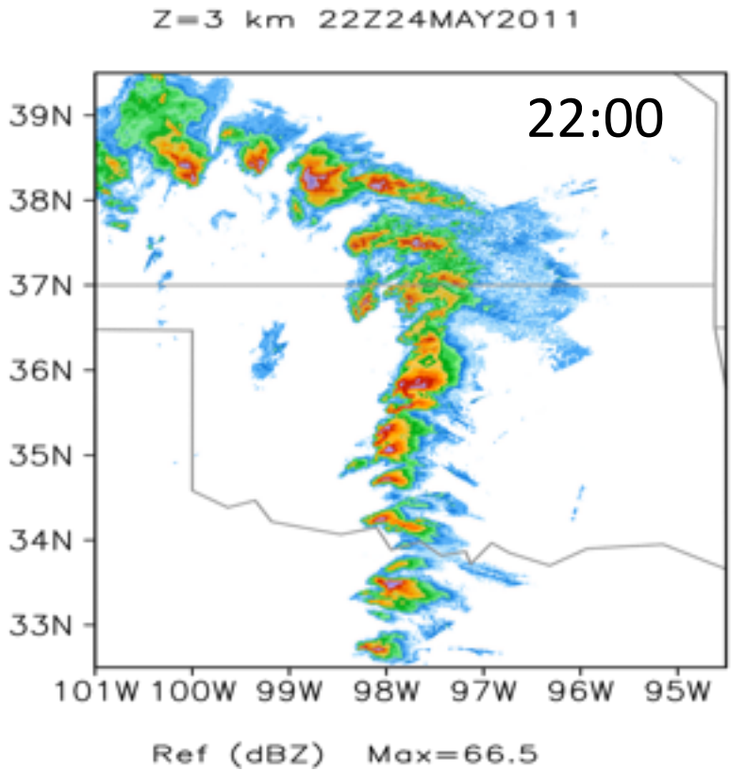
20:30-21:00 cycle, 1 hour FCST

Observed Radar Reflectivity

(Zhuang et al.)







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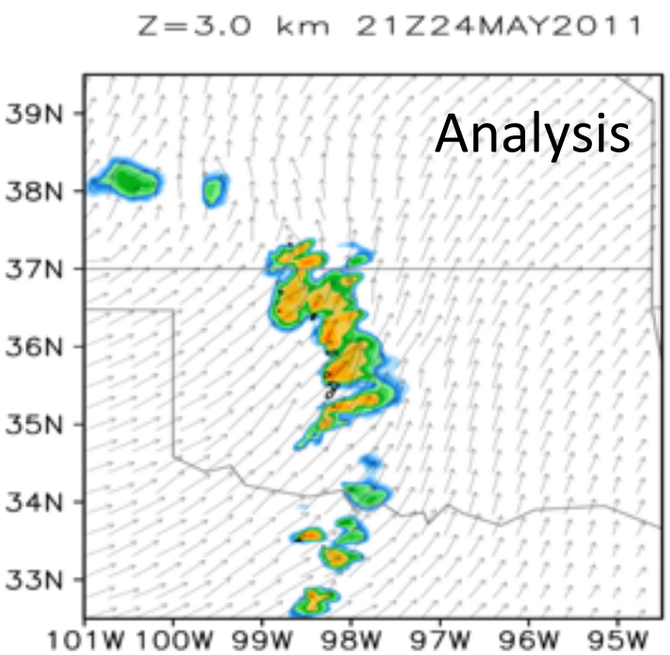
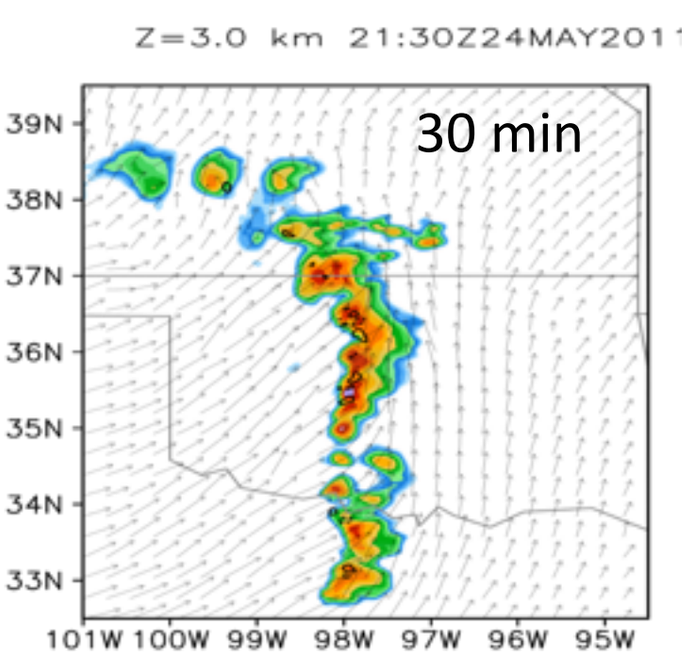
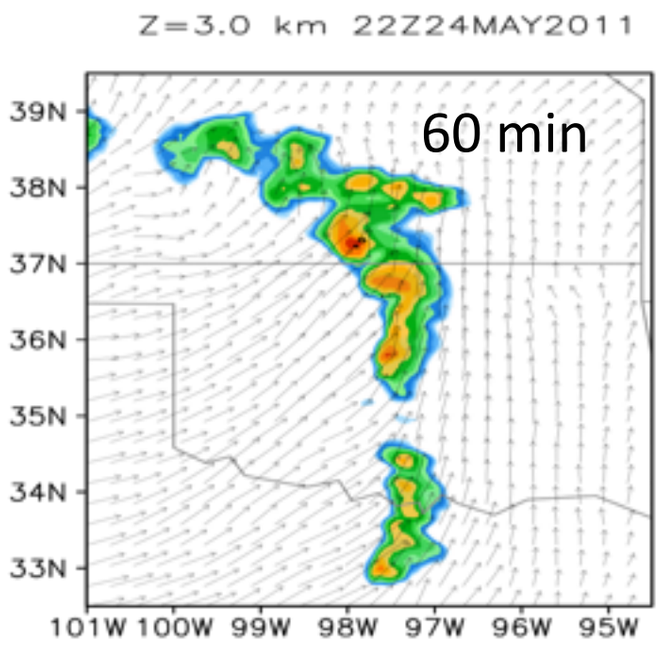
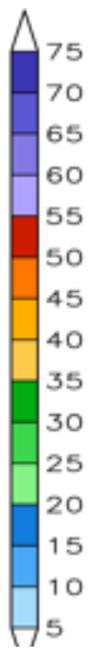






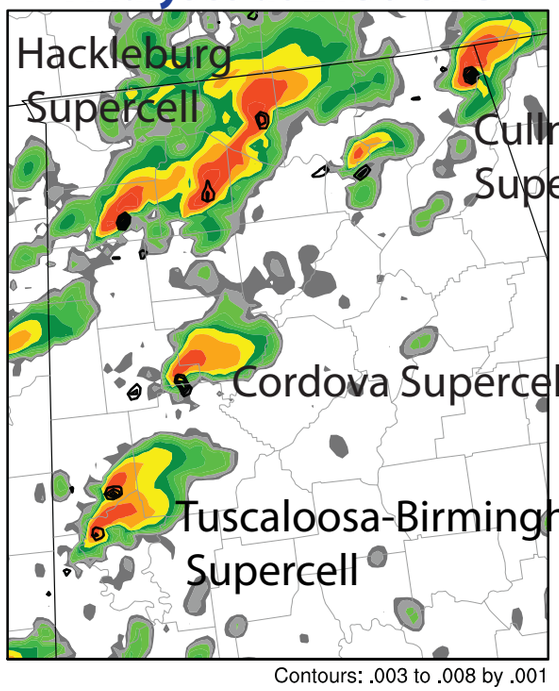


Non-Central Plains Cases

April 27, 2011

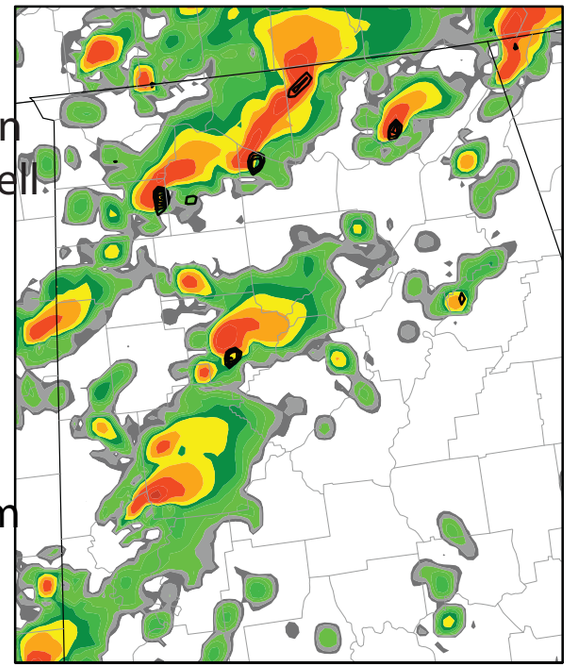
Yussouf et al

Analyses at 2130 UTC

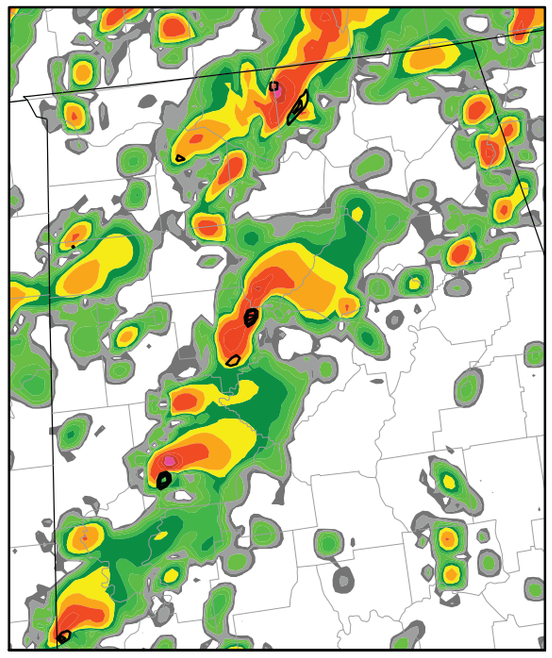


Contours: .003 to .008 by .001

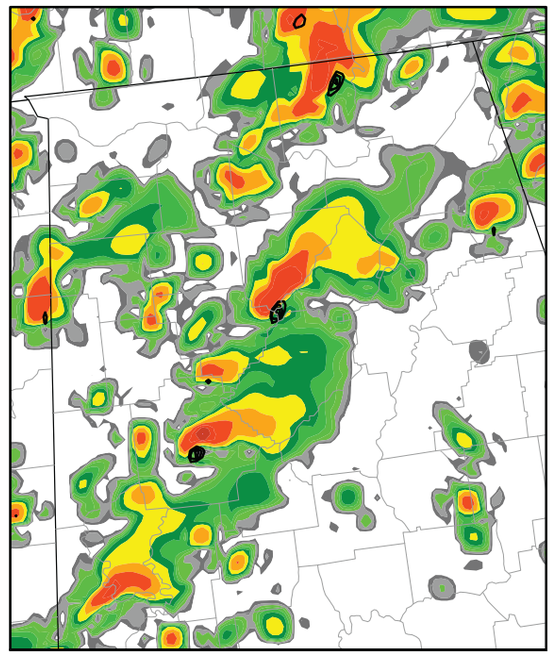
15-min Fcst valid 2145 UTC



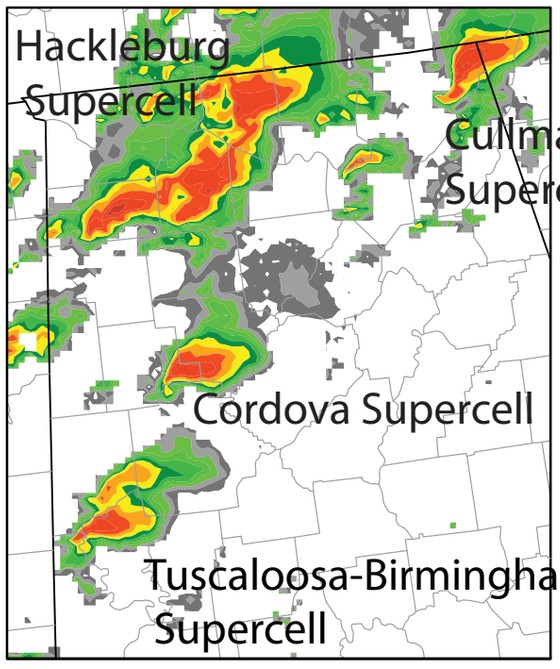
30-min Fcst valid 2200 UTC



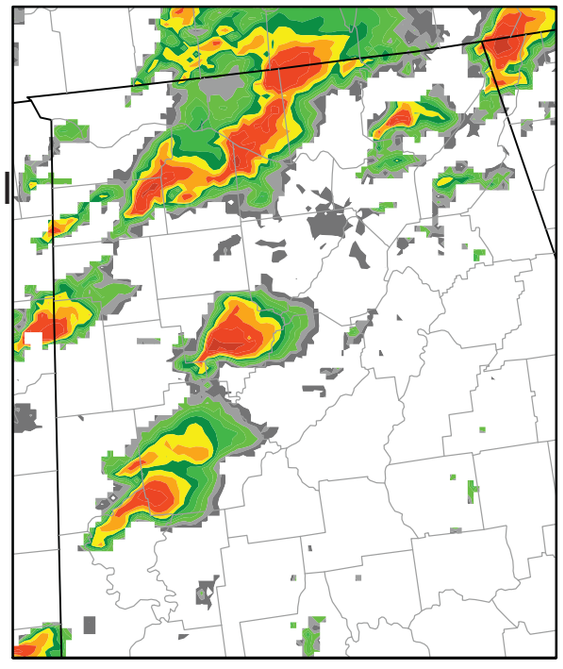
45-min Fcst valid 2215 UTC



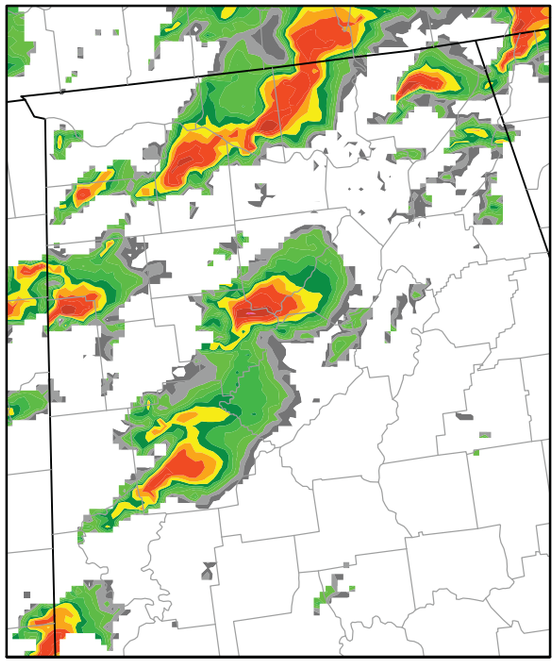
Observation at 2130 UTC



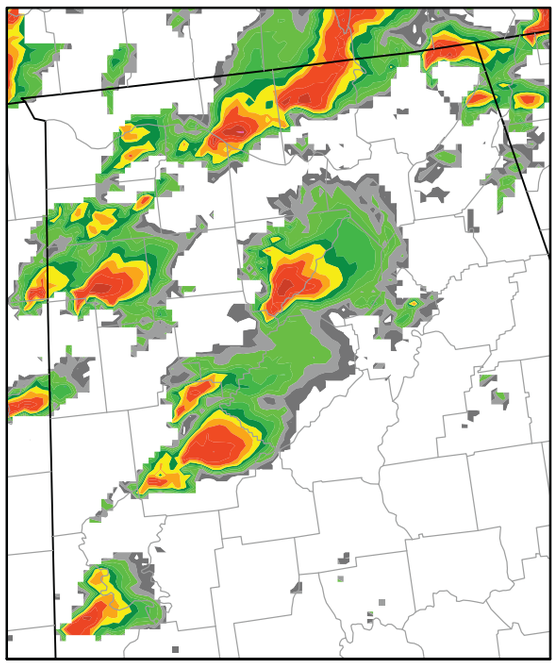
Observation at 2145 UTC

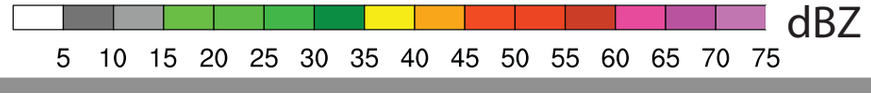


Observation at 2200 UTC



Observation at 2215 UTC

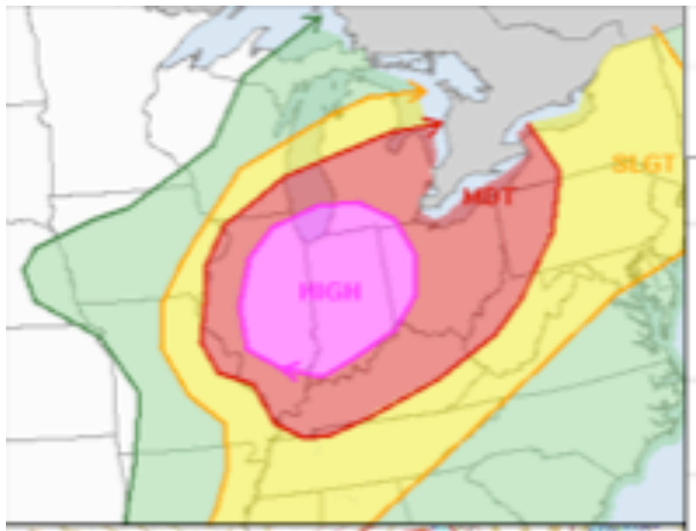


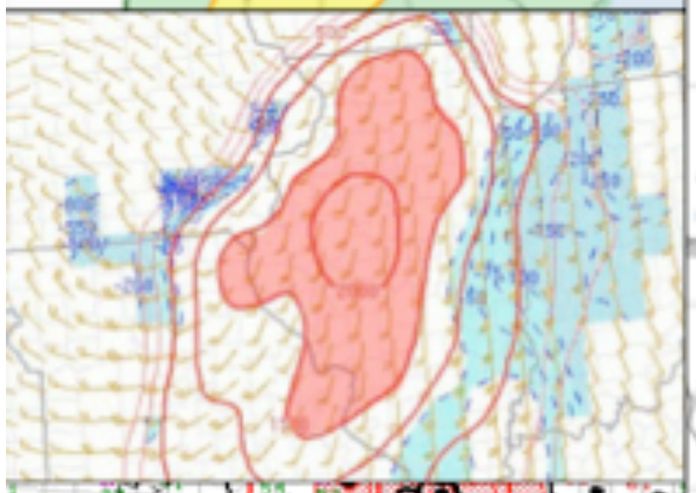


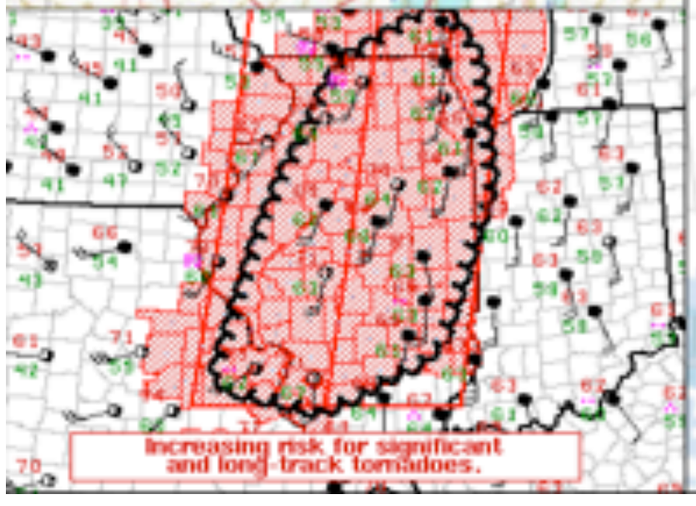
Non-Central Plains Cases

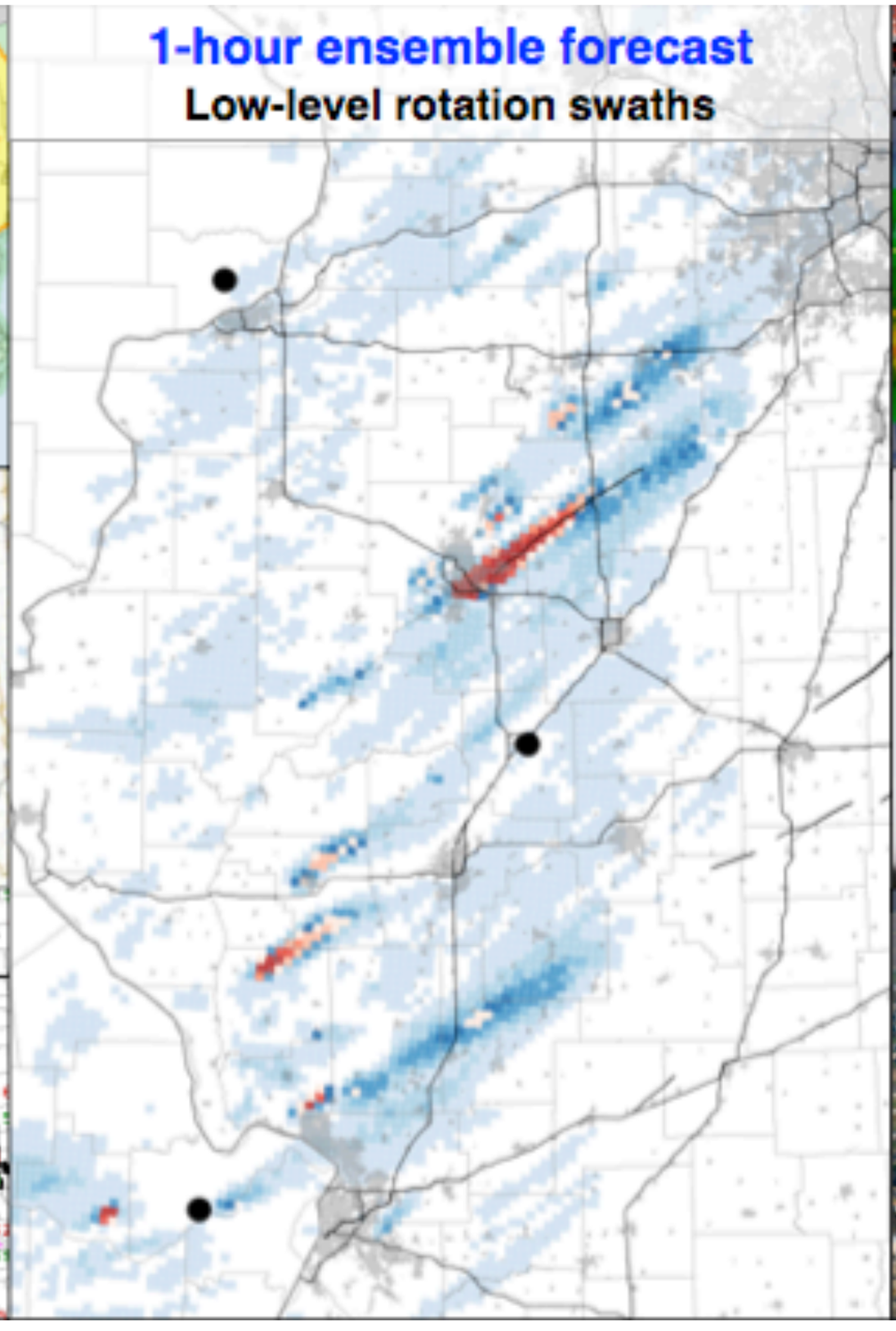
17 November 2013

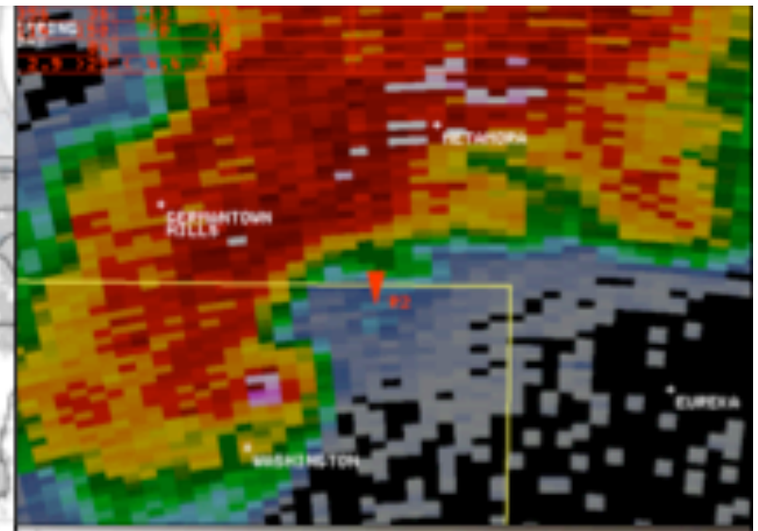
Sobash et al







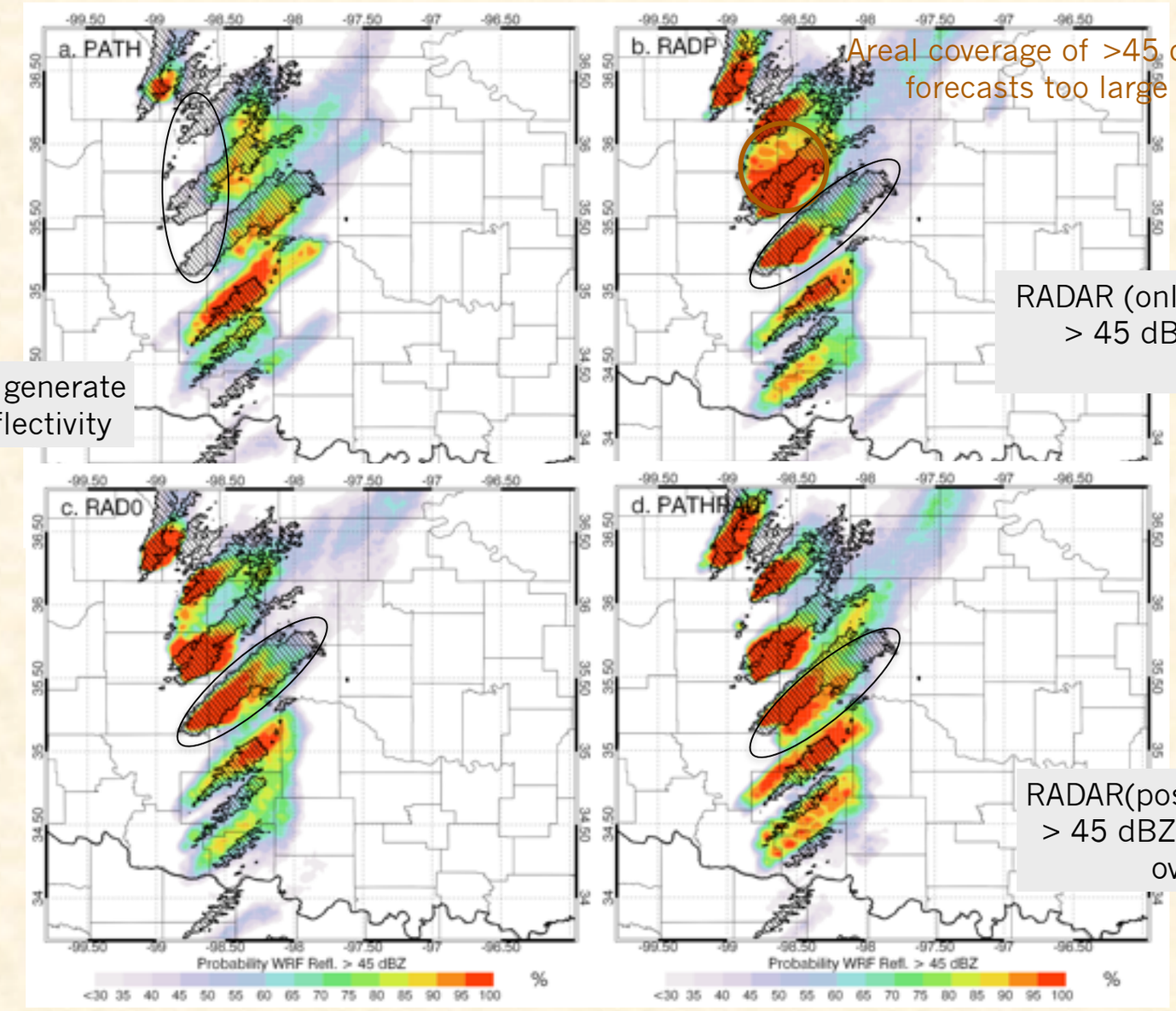




Satellite and Radar?

Jones et al

90 min forecast initialized at 2000 UTC



Areal coverage of >45 dBZ forecasts too large

Hatched areas:
Area where observed reflectivity > 45 dBz between 1930 – 2100 UTC

PATH: Slow to generate > 45 dBZ reflectivity

RADAR (only positive): Probability of > 45 dBZ reflectivity decreases rapidly

Color Contours:
Probability of simulated reflectivity > 45 dBZ between 1930 – 2100 UTC

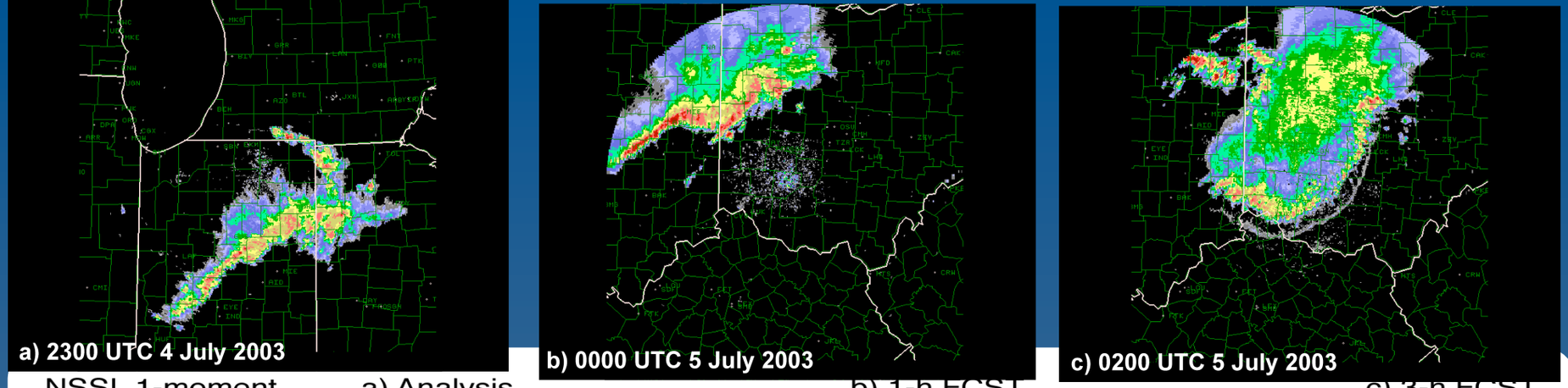
RADAR(pos) + PATH: Probability of > 45 dBZ reflectivity remains high over longer period

- **PATH:** Misses initial > 45 dBZ reflectivity areas for northern storms, but generates >80% probabilities nearby observed tracks during the 2030-2130 UTC forecast period. East bias also present
- **RADP:** ~100% probabilities near initial storm locations. Probabilities decrease quickly with what would become El Reno storm. RAD0 similar, but better with El Reno storm
- **PATHRAD:** Similar to RAD0 and RADP, but with higher probablities for southern storm tracks

Wheatley et al

BAMEX MCS Case

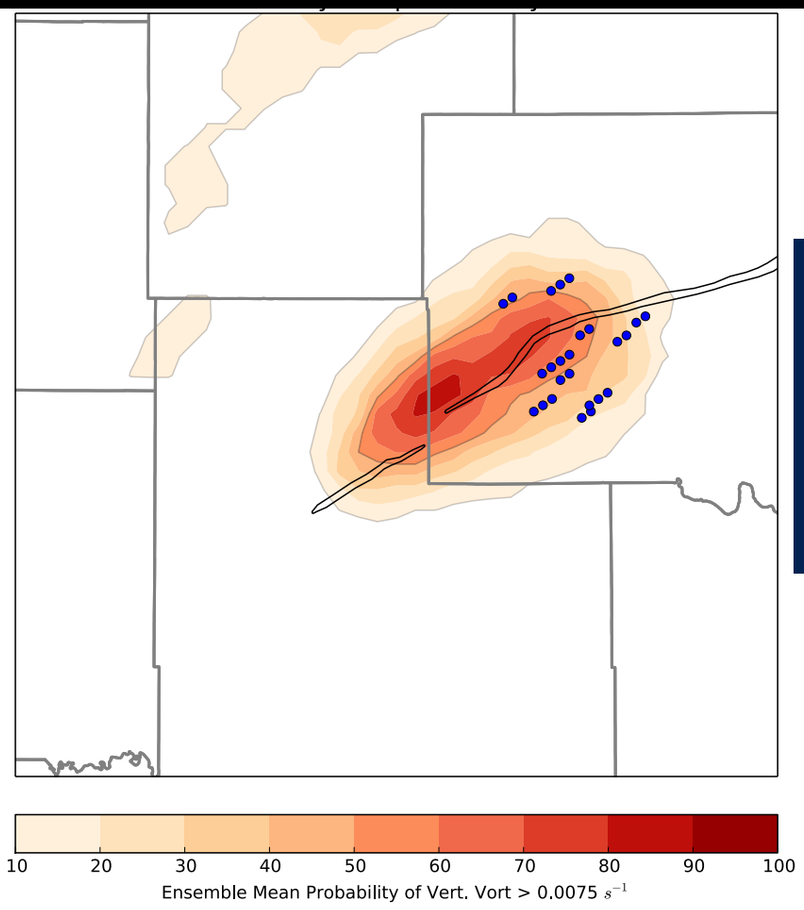
Impacts of Microphysical Scheme on Analysis and Forecast Evolution



Impact of Rapid Scan Radar (PAR) on 24 May El Reno Forecasts

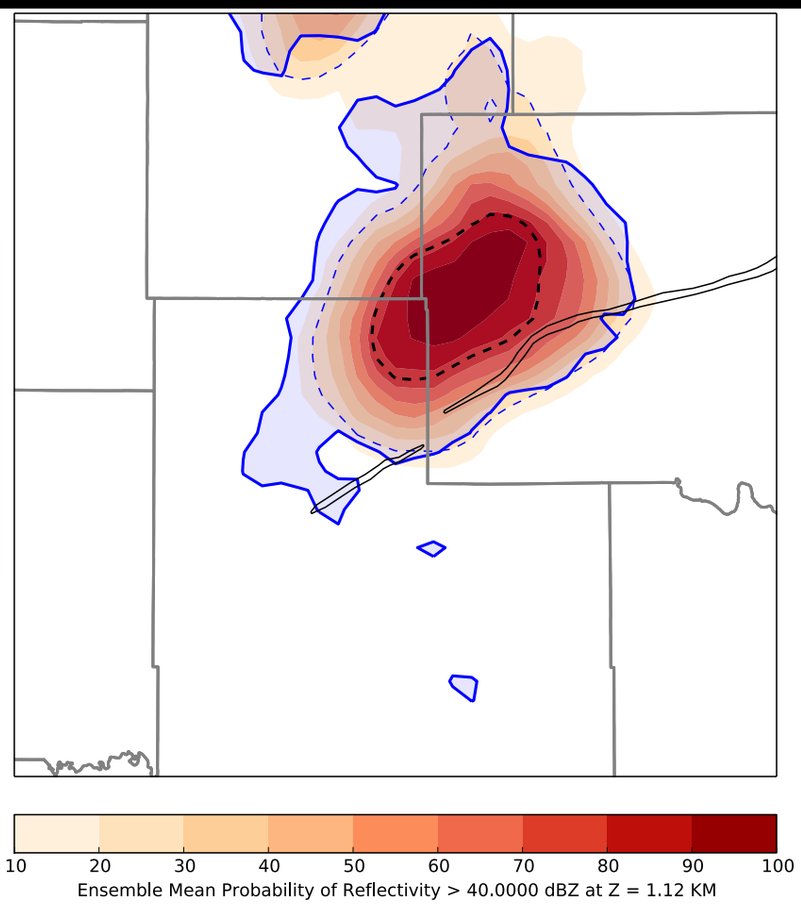
Wicker et al

0-1.5 km Mean Layer Rotation Forecast 20:20-20:50 UTC



88D 5 Volumes

1 km Reflectivity Forecast valid @ 20:40 UTC



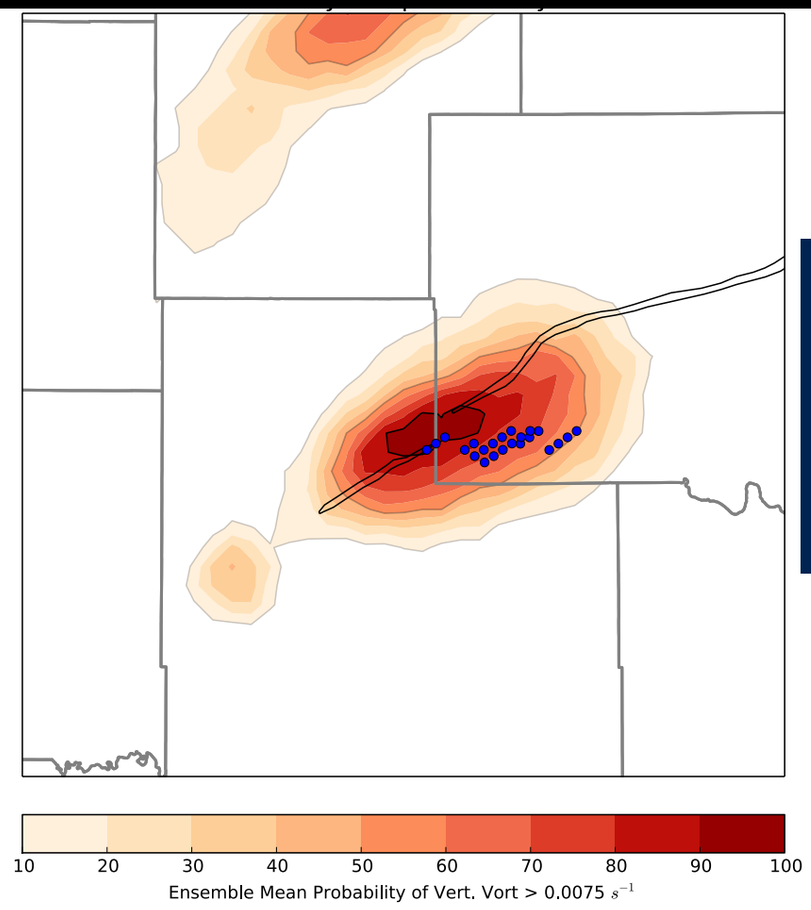
Shaded regions: Prob(ζ > 7.5×10^{-3} s^{-1})

Blue dots: members where ζ > 1.5×10^{-2} s^{-1}

Shaded regions: Prob(dBZ > 40)
Solid blue line: Observed 40 dBZ.
Thick dashed line: Mean ENS 40 dBZ
Thin dashed line: Prob(40 dBZ) > 20%

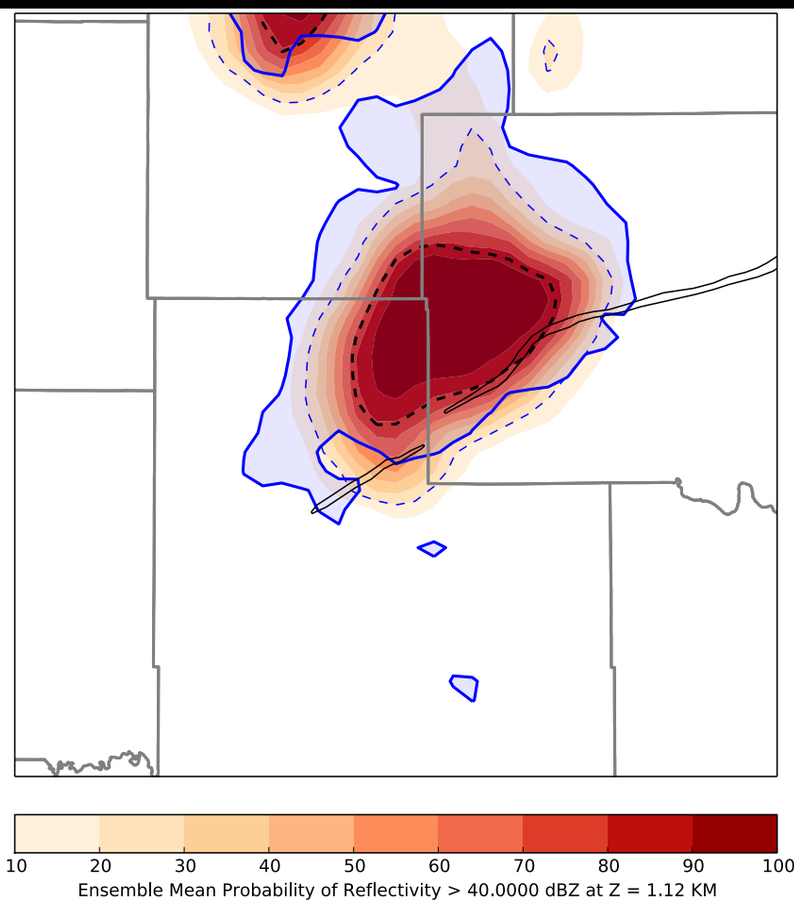
Impact of Rapid Scan Radar (PAR) on 24 May El Reno Forecasts

0-1.5 km Mean Layer Rotation Forecast 20:20-20:50 UTC



MPAR 21 Volumes

1 km Reflectivity Forecast valid @ 20:40 UTC



Shaded regions: Prob(ζ > 7.5×10^{-3} s^{-1})

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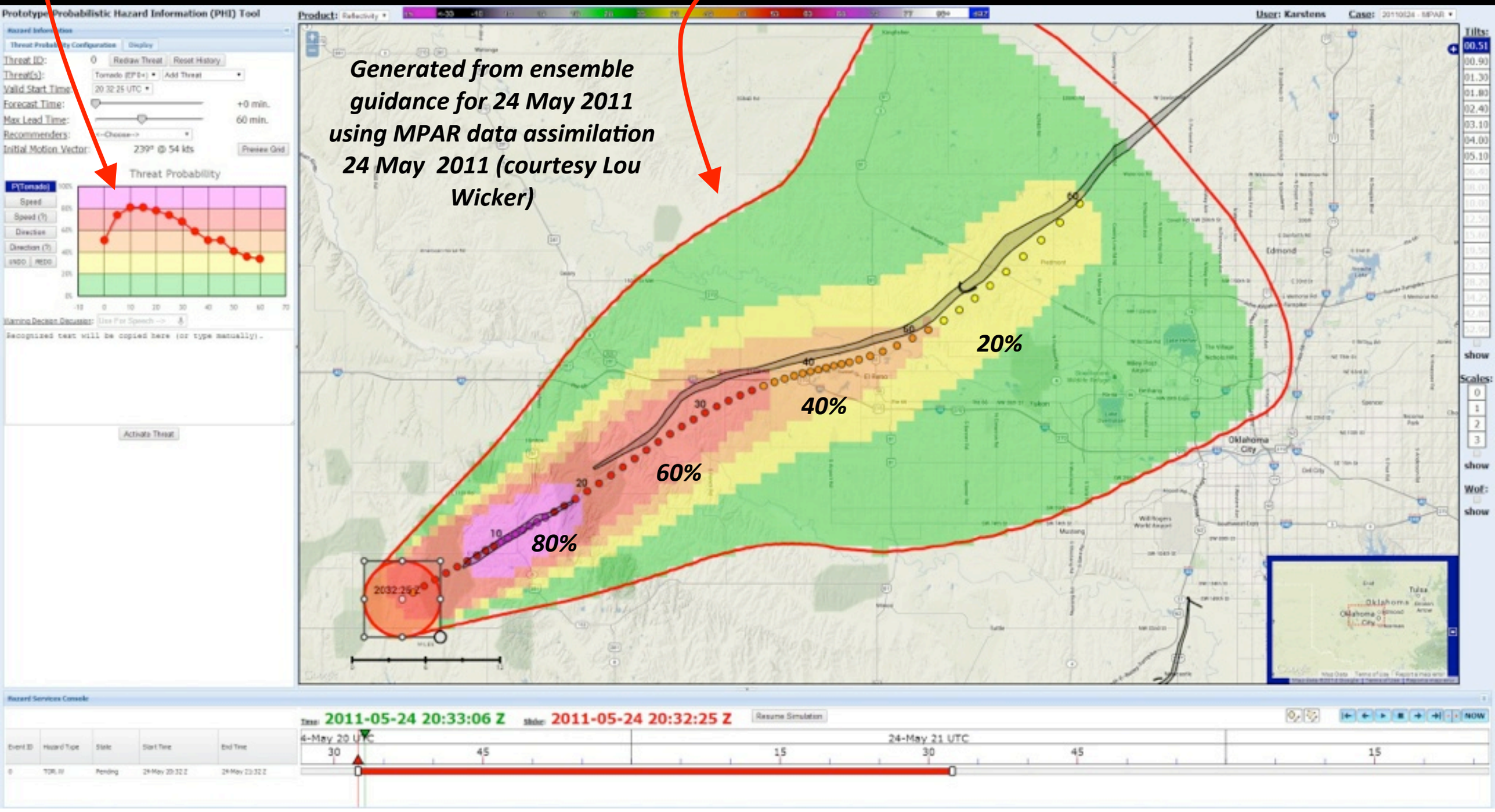
Shaded regions: Prob(dBZ > 40)
Solid blue line: Observed 40 dBZ.
Thick dashed line: Mean ENS 40 dBZ
Thin dashed line: Prob(40 dBZ) > 20%

Probabilistic Hazard Information (PHI)

Probabilities generated from ensemble forecasts can be used to inform:

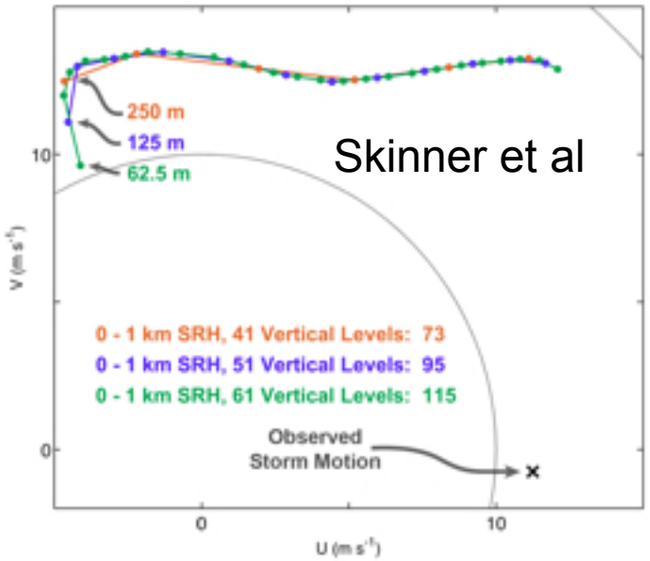
- Forecast probability of occurrence
- Forecast uncertainty of location

Prototype PHI Tool – Karstens et al.



Impact of Vertical Resolution on Forecasts of the 31 May 2013 El Reno, OK Supercell

0 - 3 km Hodographs



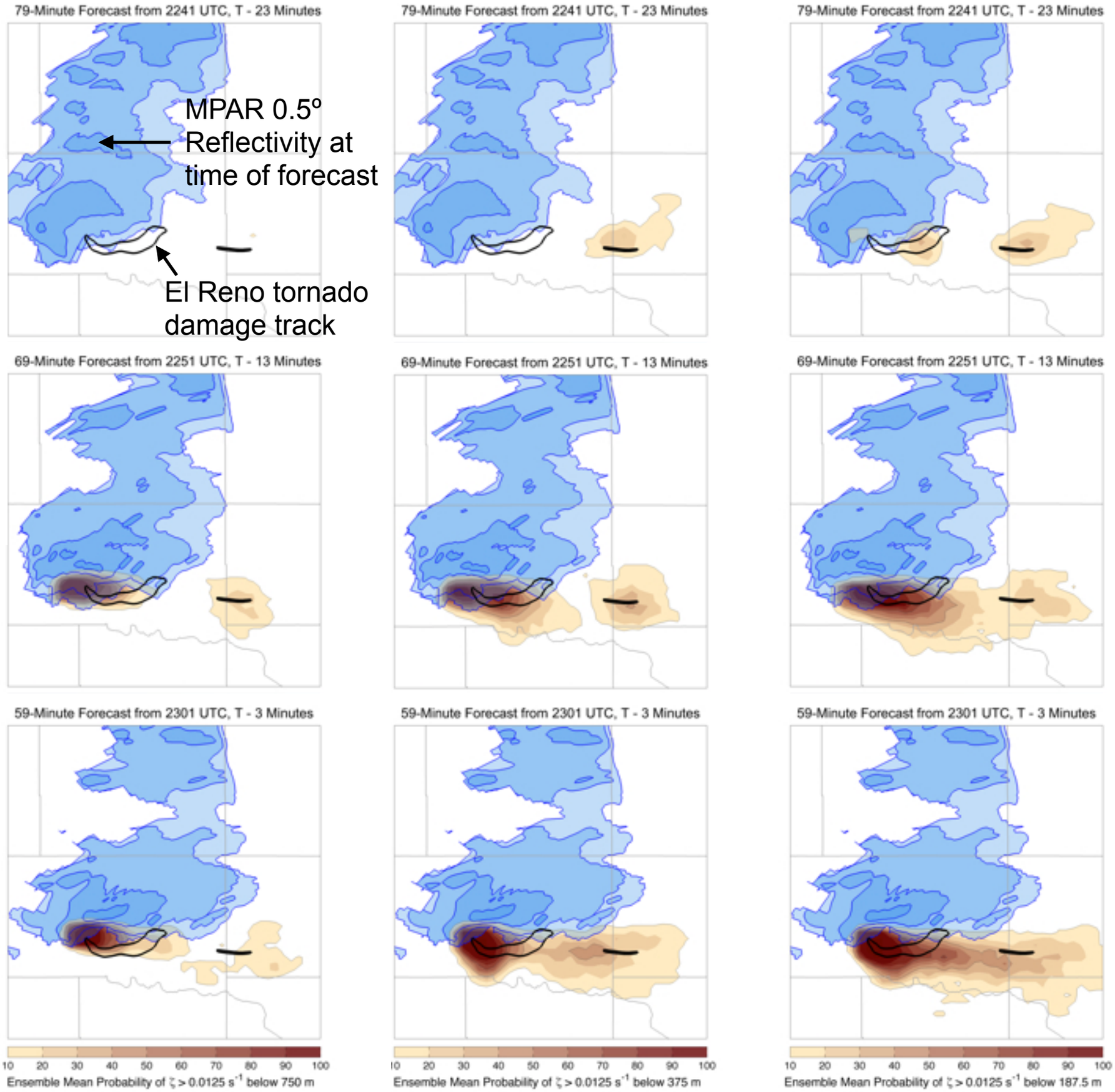
- **More vertical levels near the surface better resolves the environmental low-level wind**

- **Results in stronger environmental 0-1 km SRH and stronger predicted swaths of low-level vertical vorticity**

41 Vertical Levels
Δz = 250 m

51 Vertical Levels
Δz = 125 m

61 Vertical Levels
Δz = 67.5 m



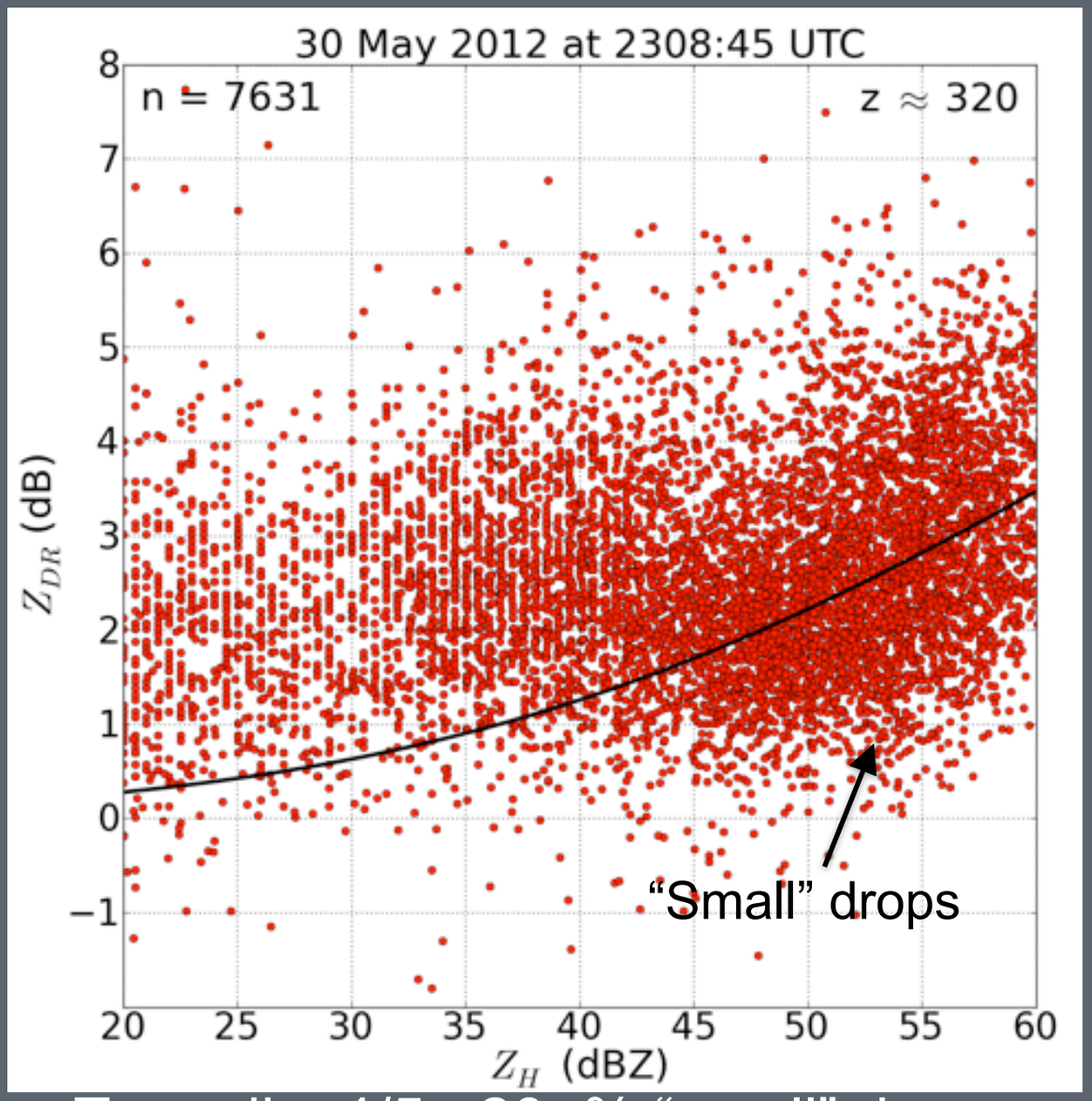
Dual-Pol Research: Hook Echo Rain Drop Sizes

15 NOXP supercell cases, 11 from V2: differences between tornadic and non-tornadic hook echoes using Z_{DR} as proxy for median drop size?

French et al

Dual-Pol Research: Hook Echo Rain Drop Sizes

15 NOXP supercell cases, 11 from V2: differences between tornadic and non-tornadic hook echoes using Z_{DR} as proxy for median drop size?

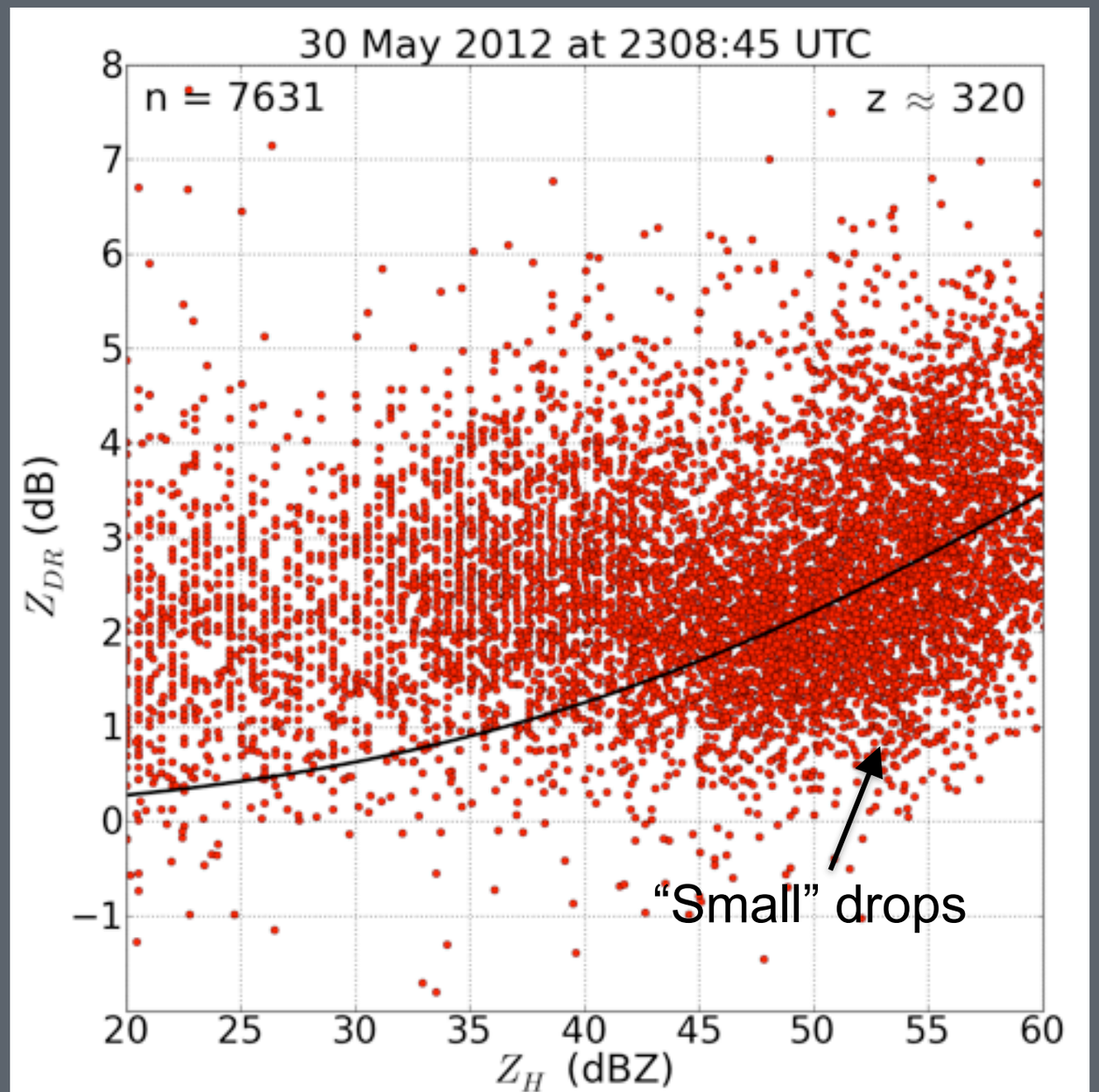


French et al

Tornadic: 4/5 ~20+% “small” drops

Dual-Pol Research: Hook Echo Rain Drop Sizes

15 NOXP supercell cases, 11 from V2: differences between tornadic and non-tornadic hook echoes using Z_{DR} as proxy for median drop size?



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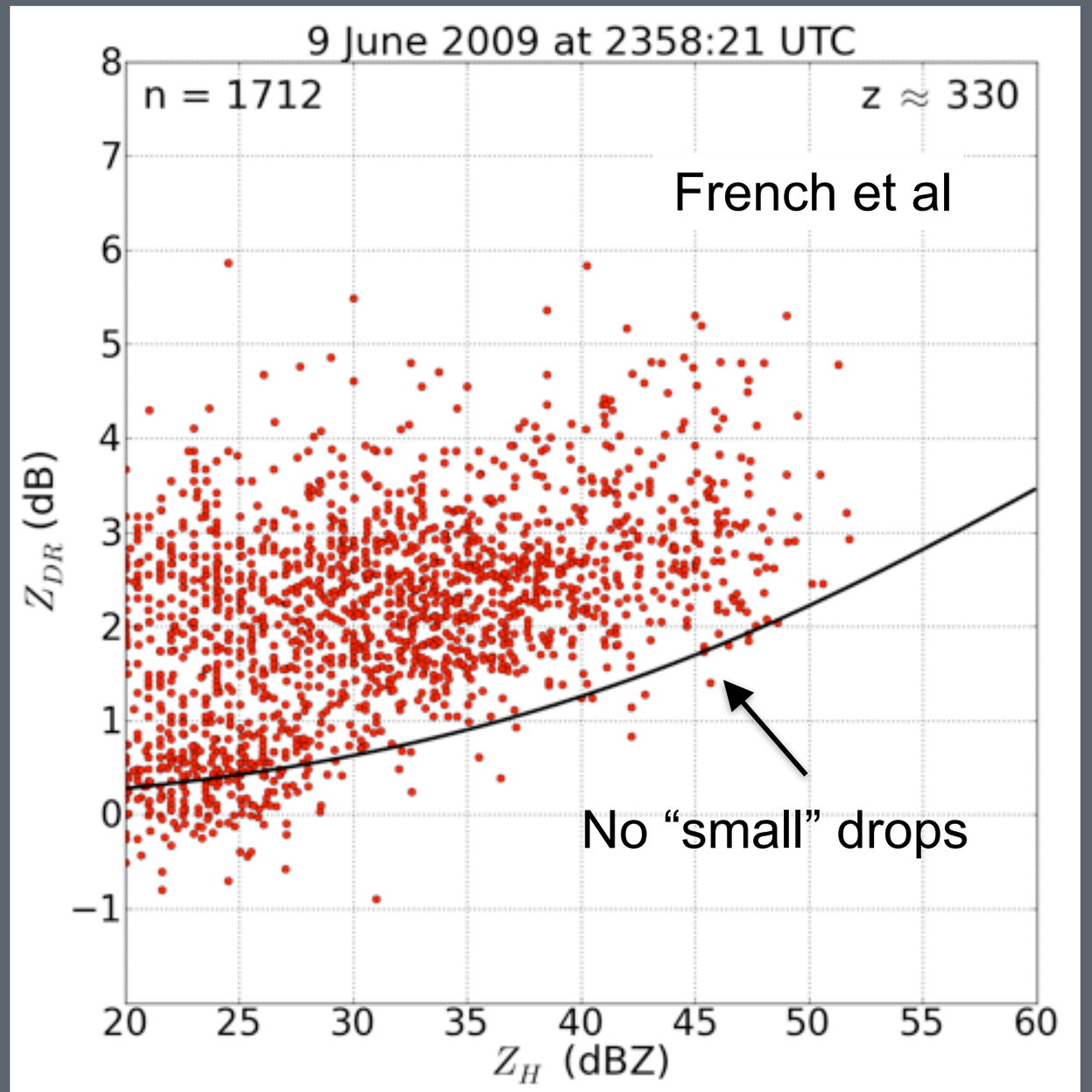

Non-tornadic: 6/10 < 6% "small" drops

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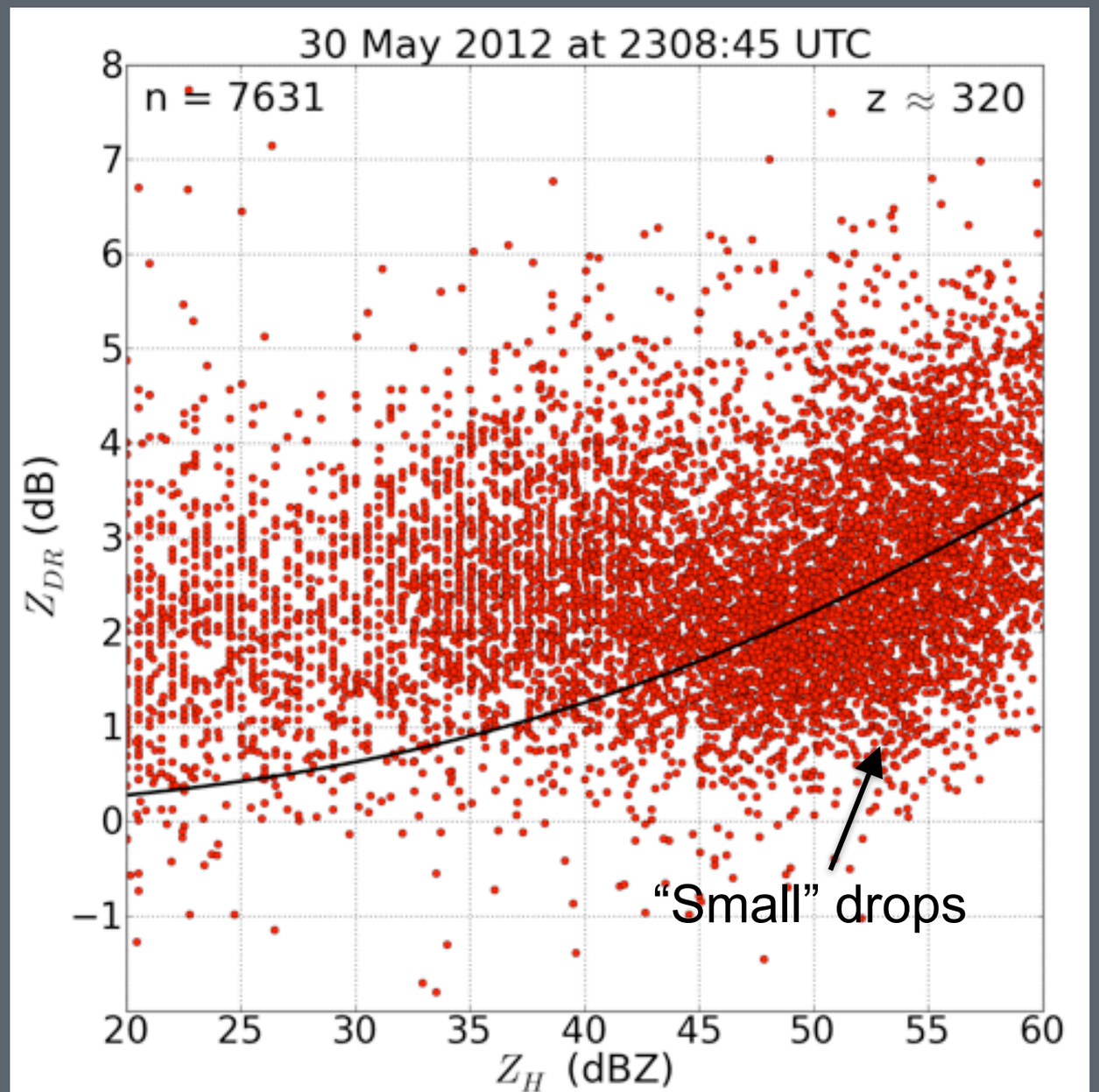

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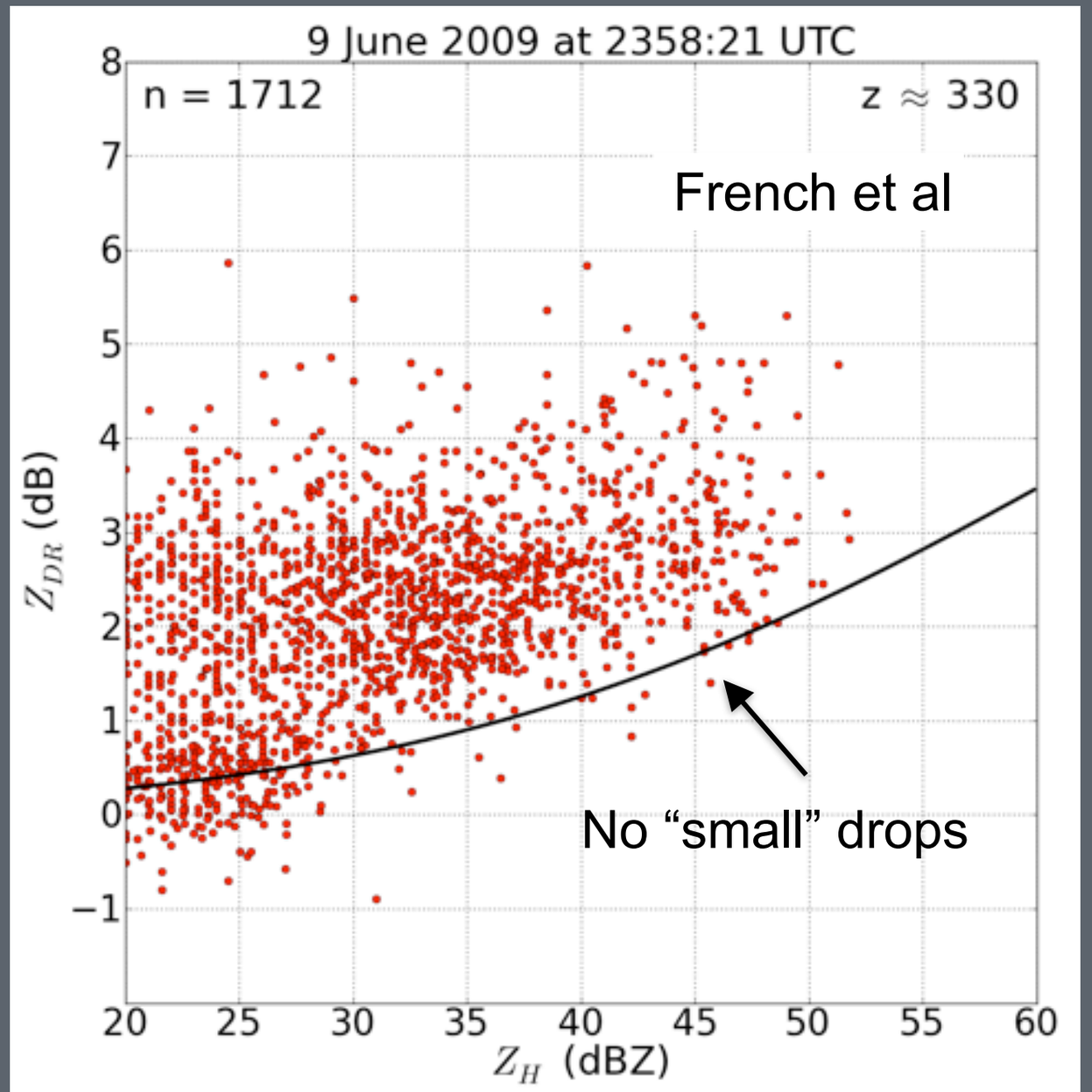

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Median LCL for small vs. large drop cases: 747 m vs. 1192 m

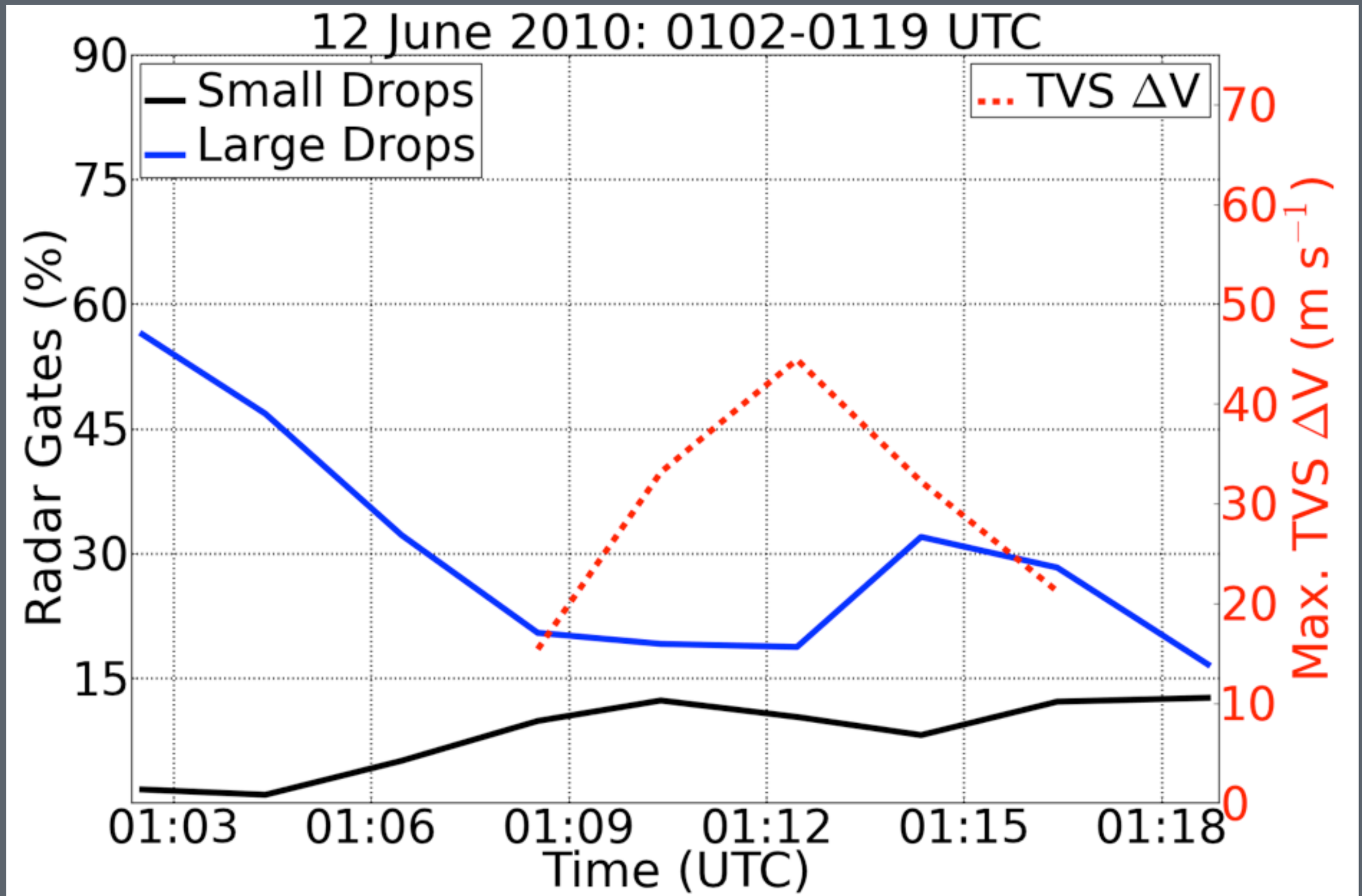
Major Take Aways

- Case Work
  - both central and non-central plains
  - establishing baseline expectations
- DA Techniques
  - Some version of Ens-3DVAR, Hybrid, EnKF still in play
  - lots of engineering left to do in the DA parameter space
  - satellite data assimilation improves convective scale!
- Methodology for background (lots of tests)
  - use GFS ensemble at 00Z for IC/BC
  - multi-physics on mesoscale
  - cycle for 12-18 hours, then nest.
  - how to do this for 24/7 WoF?
- Convective scale grids
  - assimilation high resolution radar, satellite, and surface data
  - start to get at microphysical impacts, sophstication, and possible choices
  - how to use dual-pol data (big question for future)

Questions?

French et al

Drop Sizes and Storm Processes



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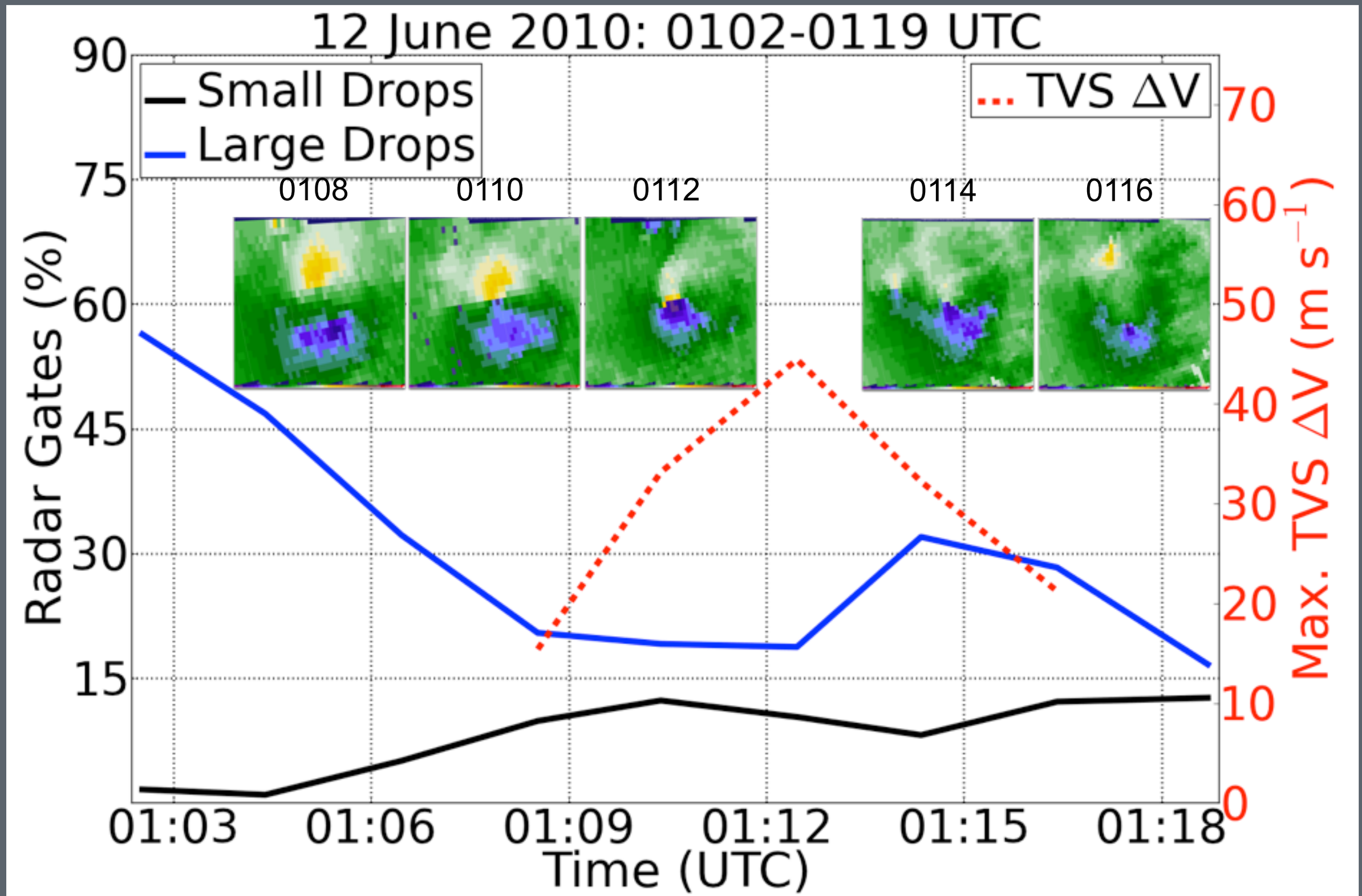

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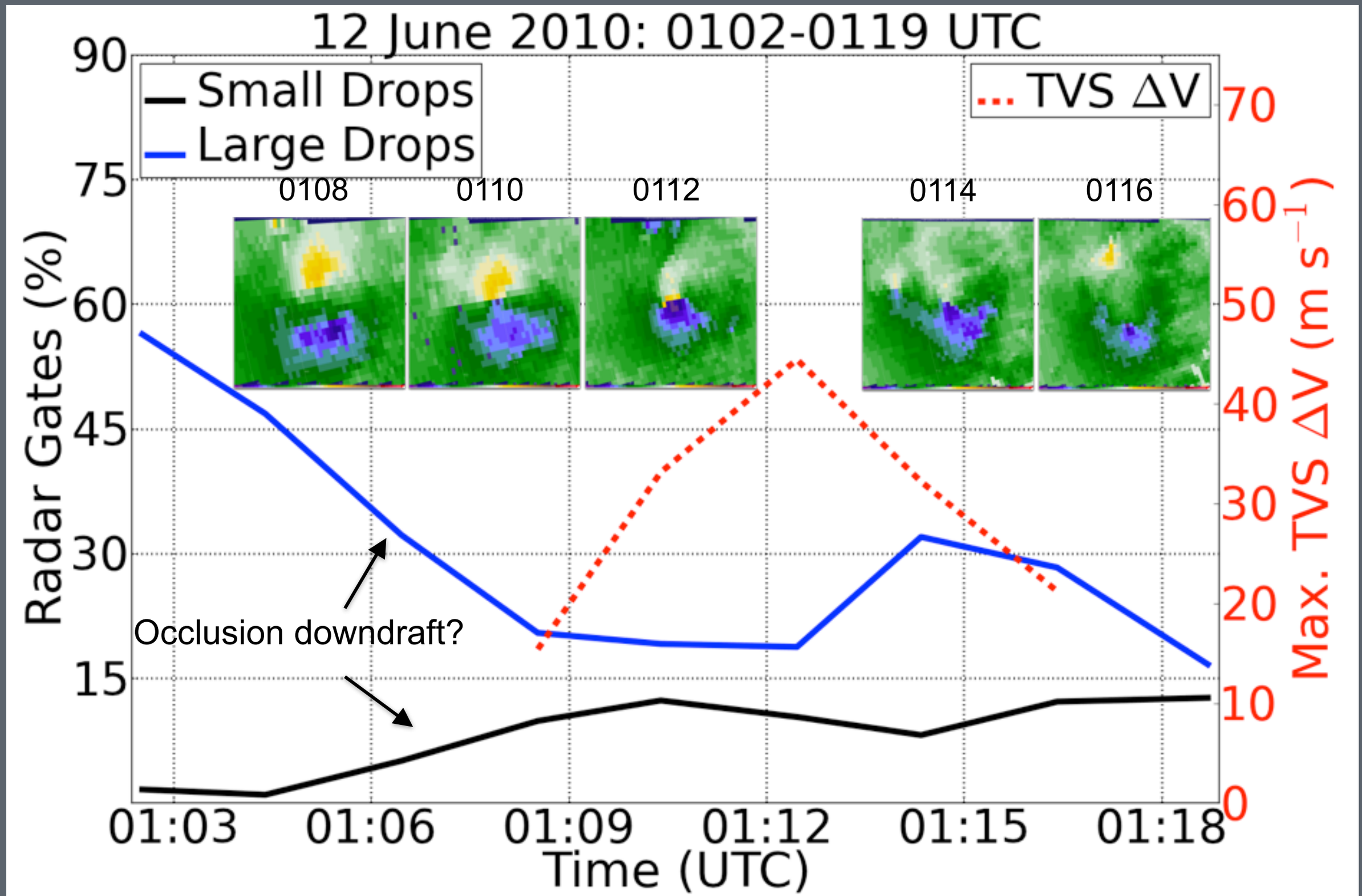
Drop Sizes and Storm Processes



~8 min prior to tornadogenesis: small drops ⬆, large drops ⬇